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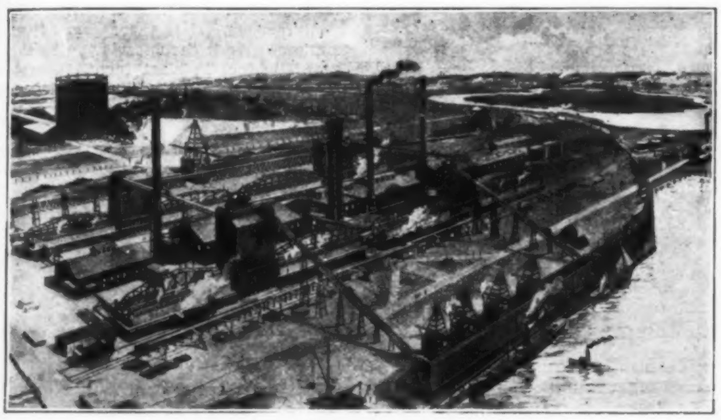
[Concluded from SUPPLEMENT No. 1633, page 26166.]

HOW COKE IS MADE.*

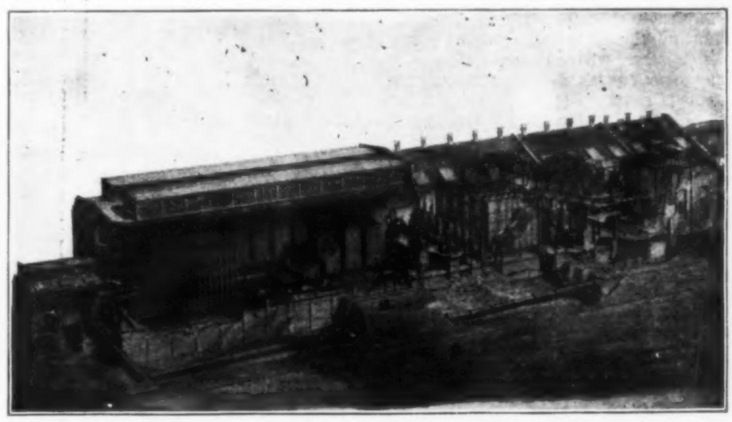
Otto-Hoffmann By-product Oven.—In 1881 the firm of Dr. C. Otto & Co. constructed and exploited in Germany an oven in which Siemens' regenerator was employed to recover the heat from the waste gases and to furnish heated air for combustion, the oven construction being of the Otto-Coppée type, then well known. This form of oven met with such acceptance that by 1894 over 1,200 of them had been constructed on the continent of Europe. In 1894 the first plant of this type was erected in the United States, a battery of 60 ovens being built for the Cambria Steel Company at Johnstown, Pa., to produce coke for use in its blast furnaces. This was therefore the first by-product oven plant operated in conjunction with a blast-furnace in the United States. Since this date there has been a steady increase in the number of Otto-Hoffmann ovens, as is shown in the table on next page.

The Otto-Hoffmann system is distinguished by the use of vertical flues in the side walls of the ovens or retorts and the utilization of the Siemens regenerator. The ovens or retorts of the usual rectangular form were built at first in batteries of 30 and later of 50. The ovens are 33 feet long, 6½ feet high, and from 17 to 22 inches wide, their capacity being from 6 to 7 net tons of coal. The walls of the ovens are sometimes built to taper, so that the oven is wider at the discharging end than at the pushing end. This taper varies from 4 inches for swelling coals to 1 inch for those of a shrinking nature. The side walls are provided with vertical internal flues, through which the ovens or retorts are heated. The heating of the oven

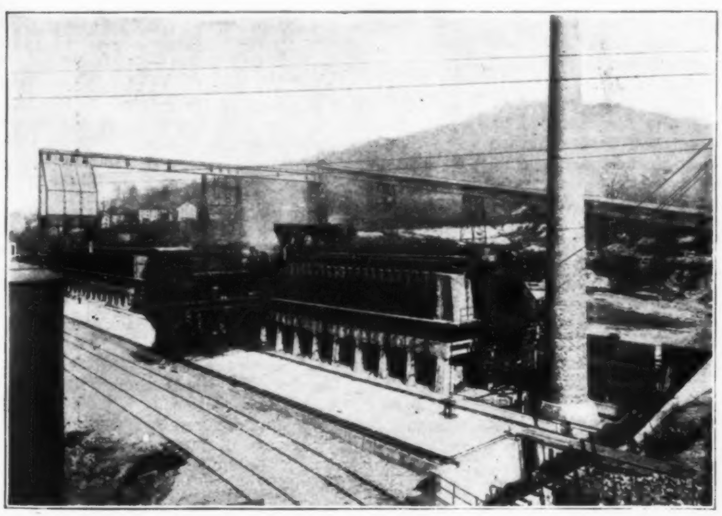
* Abstracted from Bulletin 65, published by the Bureau of the Census of the Department of Commerce and Labor.



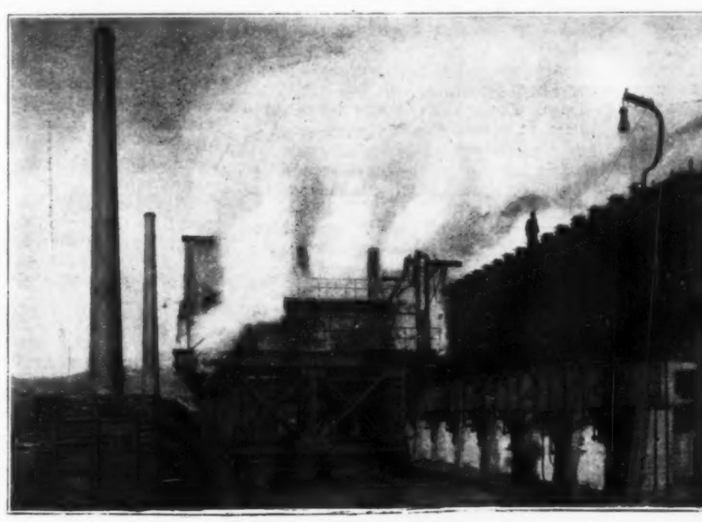
GENERAL VIEW OF PLANT AT EVERETT, MASS.



SECTIONAL VIEW OF CONDENSING APPARATUS

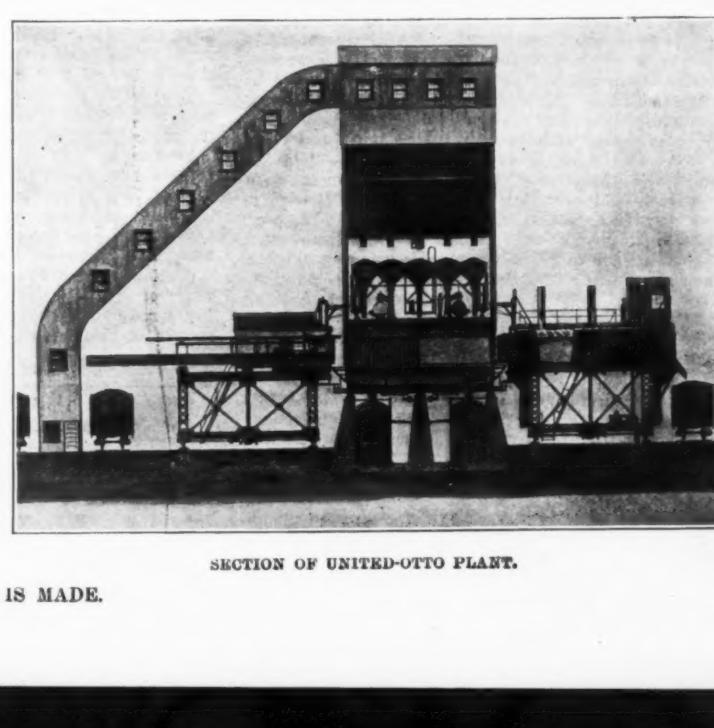


LATEST INSTALLATION OF 100 OVENS OF STEEL PLANT AT JOHNSTOWN, PA.



QUENCHER IN OPERATION.

SECTIONAL VIEW OF OTTO-HOFFMANN OVEN.



SECTION OF UNITED-OTTO PLANT.

HOW COKE IS MADE.

OTTO-HOFFMANN BY-PRODUCT COKE OVENS BUILT OR CONTRACTED FOR IN THE UNITED STATES, 1905.

Location.	Number of Ovens.	Use of Coke.	Use of Surplus Gas.
Johnstown, Pa.	372	Blast furnace	Fuel and power.
Glassport, Pa.	120	Blast, domestic	Illuminating, fuel.
Everett, Mass.	400	Domestic, locomotive	Illuminating, fuel.
Hamilton, O.	50	Foundry, domestic	Illuminating, power.
Lebanon, Pa.	232	Blast furnace	Fuel.
Buffalo, N. Y.	*564	Blast furnace	Fuel.
Camden, N. J.	100	Foundry, domestic	Illuminating, power.
Camden, N. J.	* 50	Foundry, domestic	Illuminating, power.
Sparrow Point, Md.	200	Blast furnace	Illuminating.
Wyandotte, Mich.	15	Lime kilns	Fuel.
Wyandotte, Mich.	* 15	Lime kilns	Fuel.
South Sharon, Pa.	212	Blast furnace	Fuel.
Duluth, Minn.	50	Blast furnace	Illuminating.

* Not completed.

is done by gas, returned from the condensing house through lines running along each side of the battery, there being a burner at either end of each oven. Only one burner is used at a time. The air for combustion is taken in at the end of the battery where the gas and air reversing valves are located, and is led through an underground passage to flues beneath the regenerative chambers. These chambers extend the whole length of the oven battery and are filled with checker brick. The air rising through this checker work is heated to a high degree and then passes through uptake connections to the space beneath the floor of the oven chambers, and thence through lateral ports to the combustion chamber, where it meets the gas from the burner. The burning gases rise through the vertical flues of half the oven wall, pass along the horizontal connecting flue above, and down the remaining vertical flues to the horizontal flues below, thence passing to the regenerator, where their sensible heat is absorbed by the checker work. From there they are led to the lower regenerator flue, past the reversing valve, to the draft stack. On the reversal of the air and gas the gas burner at the other end of the oven comes into use, the air passing up through the heated regenerator on that side to the gas burner and combustion chamber, the heated gases passing in the reverse direction through the wall flues, downward through the regenerator and so to the stack. The period of reversal is usually thirty minutes.

United-Otto By-product Ovens.—The United Coke and Gas Company, in its work of erecting the Otto-Hoffmann plants in the United States, has modified the original design so much that it is now building a new oven, known as the United-Otto oven. The principal change involved is the adoption of the under-fired principle, which makes it possible to heat a longer retort of greater capacity than heretofore, and also makes each oven battery an economical unit without the use of an auxiliary steam boiler to absorb the heat from the combustion gases. The construction is described in the following statement, which was kindly supplied by this company:

"The oven itself is a rectangular retort from 33 to 43 feet long, 7 to 9 feet high, and 17 inches in width, the dimensions varying with the characteristics of the coal that is to be used. The retort walls, top and bottom, are composed of refractory material, and the masonry is supported on a steel and concrete substructure, so as to be entirely independent of the regenerative chambers below. This avoids the cracking of the oven walls and the consequent loss of gas, liable to occur from the expansion and contraction of the heated regenerator walls beneath the oven structure. Access is also given to all parts of the oven for inspection and incidental repairs. The open substructure admits of a complete anchoring system joining the buck-stays above and below, and holding the oven walls securely in place. The steel work of the substructure is protected from the heated brickwork above by a course of hollow tile, which also serves to retain the heat in the ovens. The oven chamber is closed at either end by doors which are of the self-sealing type, replacing the older form of clay-luted doors. These do away with the labor of mixing and applying the luting clay, which has hitherto formed a large item in the operating expenses.

"The construction of the oven walls is a point of vital importance. Shaped brick of the best grade of refractory material of moderate size and simple design are used, complicated and irregular shapes and those of large size being avoided as being more liable to cracks and distortion. The time honored methods of laboriously chipping bricks of uneven thickness to form an even course in laying the oven walls has been abandoned entirely, and all cutting is done to exact dimensions by large carborundum grinding wheels, which economize the high-priced mason's labor and result in a quality of workmanship far beyond anything previously considered possible. This results in a practically gas tight wall of great strength.

"The resistance of the wall is enhanced by the vertical flue system, as the heating flues run perpendicularly along all that portion of the oven wall against which the coal can exert any pressure. The divisions between the flues form vertical strengthening ribs and tie the wall into a single homogeneous whole. This is of vital importance when coals of only slightly shrinking or even expanding nature are to be coked, such as are used at the Cambria plant. The greater unsupported wall area necessarily exposed to the pressure exerted by this coal in a horizontal flue system is liable to result in bulging of the side walls and destruction of the oven. A great advantage of the vertical flue construction is its ability to withstand the compression loads due to the weight of the oven superstructure, thus doing away with the necessity of supporting walls built between the heating flue systems of each adjacent oven, and decreasing the cost of the masonry, as well as saving 33 per cent of the space required for a given block of ovens.

"The heating of the ovens is accomplished, as in the Otto-Hoffmann oven, by the use of gas returned from the condensing house. The air for combustion is supplied to the regenerator by a fan, this method aiding in the equal distribution of the air to each oven and reducing the amount of stack draft necessary. This not only allows the use of a smaller stack, but makes a more even balance of the pressure in the flues and diminishes the loss of gas from an oven should a leak occur in the division wall. The gas is admitted through a burner at each end and four or six burners in the bottom, placed symmetrically on each side of the middle line. This avoids the use of bottom burners above the regenerative chambers, where they are less easy of access for cleaning and regulation. At the same time it makes it possible to heat properly ovens up to 43 feet in length, instead of 33 feet, which was the limit of the Otto-Hoffmann oven heated with the end burners alone. This results in an increase of oven capacity of approximately 50 per cent, and a corresponding saving in the operating cost per ton of output. The surface of the checker brick in the regenerators is so proportioned as to render the most efficient service in absorbing the heat from the waste gases, at the same time avoiding unnecessary cost in installation. The temperature of the waste gases leaving the regenerators is not high enough to cause deterioration of cast iron reversing valves of the usual form."

Rothberg Oven.—The Rothberg oven consists of a long, narrow, rectangular coking chamber about 16 inches wide, 6 feet 4 inches high, and 33 feet long, closed at both ends with cast iron doors lined with brick. It is of the horizontal-flue type, one set of flues serving two adjacent ovens. In the center of the flue system is a vertical wall which divides it into separate parts. The oven, as built at Buffalo, has five horizontal combustion flues in each part, with a recuperator flue for preheating the air above. At the end of each combustion flue is a burner connection for supplying gas and also a damper to regulate the amount of flame. The method of operation is as follows: Free air is admitted through openings in the top to the recuperator flue, where it is heated, and then it meets the gas at the end of the combustion flue; the flame then passes along the upper flue to the one below, continuing this zigzag course until the bottom flue is reached, when it passes through ports to the stack flue under the battery of ovens. From here it is led to the stack. This same operation is performed simultaneously at the other end of the oven, there being no reversals of the gas and air. In each port connecting with the stack flue is a damper by which the stack draft for any oven can be regulated. To maintain a uniform temperature in the flues, gas is admitted into the different flues through the burner connections in the front walls, and air can also be admitted through peepholes located near the burner connections. In the roof of the oven are openings for charging coal, and a single opening in the center passes off the gas, evolved during coking, to a gas collecting main on the top of the battery.

The ovens are arranged side by side in a battery of 47. At present there are two of three batteries in operation, and a third is ready for use. The ovens are charged with a compressed cake of coal, with a cross section slightly less than that of the oven and a length a few feet shorter, the cake being delivered to the oven in a charging box. When coked, it is pushed out of the oven by an electric pusher onto a quenching pan, and from there put into cars and taken away. There were 94 Rothberg ovens reported in operation in 1904 and 141 in the process of construction.

USES OF COKE.

While certain minor uses are found for coke, such as an acid-proof distributing medium in chemical works, or as a filtering medium, its most important use is as a fuel and reducing agent, and its greatest consumption is found in metallurgy. It is not a uniform product, but varies with the composition and physical condition of the coal from which it is produced and the manner in which it is made. It may be classified as follows: Metallurgical coke, which includes furnace coke and foundry coke; fuel or domestic coke, which includes egg, stove, and nut coke.

Furnace coke is designed for use in blast furnaces. It should be strong enough to resist the burden of the furnace, not so brittle that it crushes easily in handling in transportation or under the load of the furnace, sufficiently porous to permit the gases to permeate its mass, but so resistant that it may reach the zone of reduction in the furnace without any serious loss from reaction at incandescence with the carbon dioxide rising through the charge. Furnace coke is sometimes spoken of as 48-hour coke.

Foundry coke is used largely in cupola furnaces, and as it must there withstand the weight of the pig iron which is to be melted, it is a denser and stronger coke than that used in blast furnaces. Foundry coke is sometimes spoken of as 72-hour coke. According to Stammler,* "Coke for foundry use must be studied from various standpoints. If the cupola is of a low-tuyere type and long heats are taken off, a heavy coke is necessary to furnish sufficient fuel in small bulk to melt the metal and still hold the melting zone in proper position for economical work. Even should a light and strong coke hold the iron without crushing, it might not be possible to get enough of this coke in a low-tuyere cupola to melt the iron and retain the next charge at its proper height. On the other hand, a strong, light coke in a high-tuyere cupola is satisfactory and economical. It takes less coke to hold the iron at the proper melting zone, is more permeable to the blast, burns freer, and melts the iron faster than does heavy coke. Coke should, therefore, be divided into two classes, and recommended according to their density, for high-tuyere or low-tuyere cupolas, as the coke is light or heavy."

According to Dewey,† "The credit of the first systematic investigation of the physical properties of coke belongs to John Fulton, mining engineer of the Cambria Iron Company." This investigation was begun in 1875, and it is now universally admitted that the physical characteristics determine largely the value of a coke. Fulton states‡ that the structure of coke consists of a series of irregular, promiscuously disposed cells, with vitreous walls, these cells being connected by diminutive passages that afford free courses for the oxidizing gases of the blast furnace. It is these hard, vitreous cell walls in coke that give it the superior value it possesses as an energetic fuel in blast furnaces. "From the foregoing it will be evident that the physical structure of coke, other things being equal, is the main element that confers on it the superior place it holds among blast furnace fuels. The same is true, in a modified way, of charcoal fuel. The anthracite holds the lowest rank." Thus the desirable ratio between the cellular space and the cell walls or body in a given volume of the coke has been carefully determined, and it is 43.73 per cent of body to 56.27 per cent of cellular walls. On the other hand, the chemical composition is of importance, as any impurities in the coke may enter the metal which is to be reduced or may form slag, and thus require a certain quantity of flux to prevent a waste of metal. It is well known that coal contains ash, sulphur or sulphur compounds, and phosphorus compounds, and these will be to a certain degree retained by the coke. A coke containing not more than 10 per cent of ash can be regarded as an average clean fuel, and those containing only 5 to 7 per cent of ash, as exceptionally pure. The sulphur in coke for use in metallurgical processes should be less than 1 per cent. The best coke contains only 0.5 to 0.75 per cent of this element. The purest varieties of coke contain from 0.012 to 0.029 per cent of phosphorus. Often as much as 40 per cent of the sulphur in the coal is volatilized in the coke oven, but as a rule all the phosphorus in the coal goes into the coke. Often a large part of the sulphur and some of the phosphorus may be removed by washing the coal before coking it. Domestic or fuel coke need not be so free from these foreign bodies and it may be denser and softer. In such a coke readiness in combustibility and, when hot, solubility in carbon dioxide gas are desirable, as, for instance, in producers when coke is used for making gas.

Besides being used in gas producers and water gas generators, coke is being largely used as a fuel for locomotives, especially in New England. It is also being crushed to size, screened and bagged for use as domestic fuel. According to the United Coke and Gas Company,§ "Of the large output of the New England Gas and Coke Company, at Everett, Mass., some 200,000 gross tons per year are disposed of for domestic and industrial service, a similar amount being used for firing locomotives, particularly in suburban service, because of its smokeless nature. The same outlet has been found for the output of the Camden plant, a portion of which, however, is sold for foundry purposes." The fine coke, or braize, made in the handling and crushing of the coke is used directly under steam boilers, or it is made up into briquettes, although some is employed in lining steel furnaces. The amount and value of the coke consumed in each branch of the iron and steel industry, together with the per cent which this quantity forms of the total output, are given in the table for each census year from 1880 to 1905.

From a table of statistics given by J. M. Swank,‖ showing the extent to which different fuels have been used in the United States for iron smelting, it appears that prior to 1855 charcoal was supreme, the quantity

* Report on Coal Testing Plant, Part III., page 1369.
† Trans. Am. Ins. Mining Eng., 1884, vol. 12, page 111.
‡ Coke, by John Fulton, 1905, page 329.
§ Short Treatise on the Destructive Distillation of Bituminous Coal, 1906, page 101.
‖ Manufacture of Iron in All Ages, page 284.

QUANTITY AND COST OF COKE CONSUMED IN THE IRON AND STEEL INDUSTRY, 1880 TO 1905.

Branch of Industry.	Quantity in Short Tons.				Cost.				Per Cent of Total Product.			
	1905	1900	1890	1880	1905	1900	1890	1880	1905	1900	1890	1880
All branches	20,378,452	17,662,072	9,707,353	2,315,560	$59,136,419	$40,991,400	$28,752,972	$8,743,392	81.0	90.0	97.9	84.1
Blast furnaces	19,739,676	16,753,480	9,402,898	2,166,200	$57,127,027	$38,976,770	$27,435,780	$8,129,240	78.5	85.3	94.0	78.7
Rolling mills and steel works	638,776	928,516	293,051	142,605	2,009,392	2,014,390	1,311,588	582,901	2.5	4.7	3.9	5.2
Forges and bloomeries	....	67	1,404	6,695	....	240	5,604	31,241	......	(*)	(*)	0.2

* Less than one-tenth of 1 per cent.

used exceeding that of either anthracite coal or coke, but in that year the consumption of anthracite exceeded that of charcoal; in 1869 the consumption of coke exceeded that of charcoal; in 1875 the consumption exceeded that of either charcoal or anthracite coal; in 1880 the consumption of coke exceeded that of both charcoal and anthracite combined, and this supremacy of coke has been maintained and extended ever since.

The account for the consumption of coke in the United States in the census year may be thus set forth:

	Short tons.
Coke produced	25,143,288
Coke imported	219,529
Total	25,362,817
Coke used in iron and steel industry	20,378,452
Coke exported	616,273
Coke used for all other purposes..	4,368,092
Total	25,362,817

USES OF BY-PRODUCTS.

The ammoniacal liquor coming from the washers contains from 0.5 to 2 per cent of ammonia existing in a variety of compounds. It is so weak it must be further treated before it is marketable. On subjecting it to heat, part of this ammonia, known as free ammonia, comes off and may be collected in water. The rest may be liberated by heating the liquor with lime or some other alkali. The treatment then consists in distilling the liquor with lime and either collecting the distillate in sulphuric acid so as to form ammonium sulphate, or else condensing it with sufficient steam to form a strong liquor containing from 15 to 20 per cent of ammonia. The ammoniacal liquor from by-product coke ovens, gas works, boneblack factories, and blast furnaces is the chief source of the ammonia water, anhydrous ammonia used in refrigeration, and the ammonium compounds of commerce. Ammonium sulphate is used in the manufacture of alum and other compounds and as an ingredient of fertilizers. The quantity of ammonium sulphate reported as used in the present census year in fertilizers was 21,080,000 pounds. The total product of ammonium sulphate reported for that year was 31,546,763 pounds, and the amount imported 30,576,558 pounds, or a total of 62,123,321 pounds, so that but slightly over one-third of the available supply was consumed in the manufacture of fertilizers.

The tar which results from the dry distillation of coal is a mixture of a variety of hydrocarbons, amines, phenols, and other organic substances together with free carbon, and it varies both with the character of the coal treated and the manner in which it is treated. By-product coke coal tar differs from gas-house coal tar in that it contains only about 14 per cent of free carbon, while gas-house tar contains as much as 28 per cent. This is due to the much higher temperature of the gas retort, the greater rapidity with which the maximum temperature is attained, and the smaller charge used. The percentage of tar acids is also greater in gas-house tar than in coke-oven tar. The tar acids from coke-oven tar contain a high percentage of cresol, thus necessitating many distillations in order to produce pure phenol. Coal tar is the source of many organic substances, such as artificial dyestuffs and photographic and pharmaceutical chemicals. In the crude state it is used in making tarred paper, paint, and varnishes for coating bricks; and as a fuel, being equal, weight for weight, to crude petroleum in fuel value. Five pounds of tar are practically equal to from 7 to 8 pounds of coal. When heated to 250 deg. C., to drive off the volatiles, coal tar pitch is produced, which is used in making tar macadam pavements, about 2 gallons being used per square yard of finished road. According to Pennock,* "as a consumer of tar, the tar macadam for 1903 will absorb 4,000,000 gallons, or the product of the dry distillation of 400,000 tons of coal." The tar macadam laid in the United States in 1901 by a single company was 14,400 square yards; in 1902, 440,000 square yards; laid and contracted for in 1903, 2,001,000 square yards, so that this industry is a constantly growing one. Coal tar pitch is also used for briquetting. In distilling the tar to obtain the pitch the distillate is divided into two portions—that which is lighter than water and that which is heavier. The light oil is redistilled for benzol and solvent naphtha. The heavy oil is in demand for creosoting timber. Two grades of pitch are usually made—paving pitch and roofing pitch.

The volume of gas evolved from a by-product oven is determined directly by the quantity of volatiles in the coal used and the heat applied. The quantity necessary to be returned to heat the ovens varies also with the coal. If the coal contains 32 to 34 per cent of volatile matter, from 50 to 55 per cent of the gas must be returned, but less gas suffices for those containing less volatile matter. The composition of the gas varies throughout the operation, it being richer in illuminants, methane, and carbon monoxide at the beginning. In separating the gas, in order to sell the surplus, the first running from 22 down to 14 candle-power are taken. This comes off on an average in the first ten hours of the operation. The rest of the gas, known as the lean gas, is that which is used in heating the coke ovens. Sometimes the benzol is removed from this lean gas and added to the surplus gas to enrich it—that is, to increase its candle-power. The benzol is removed by scrubbing the gas with tar oil, which dissolves it, and then recovering the hydrocarbon from the tar oil by fractional distillation. Gas from by-product plants is sent considerable distances. The plant at Everett, Mass., supplies Boston and the surrounding cities; from Sparrow Point, Md., the gas is pumped 11 miles to Baltimore; from the Camden, N. J., plant it is pumped 38 miles to Trenton; and the Duluth plant supplies the cities of Duluth and Superior.

* Loc. cit., page 788.

MULTIPLEX TELEPHONY.*

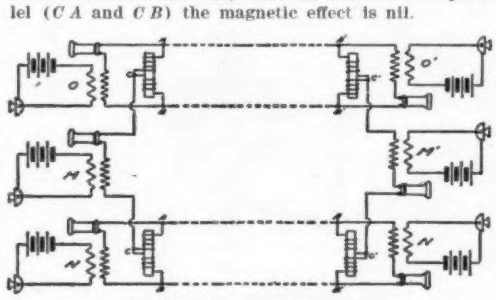
By CHARLES S. WALDEN.

It is but natural that those of an inventive turn of mind should have made attempts early in the development of the telephonic art by which a telephone circuit might be used for several simultaneous conversations without interference.

Quite a number of the ideas developed have their fundamental principle contained in a patent for a "telegraph circuit" issued to Frank Jacob in England in 1882 and in this country in 1883 (No. 287,288). This is a plan by which two metallic circuits are combined through proper resistances, arranged on the principle of a Wheatstone bridge, so that a third non-interfering circuit is formed, using the earth for one conductor and the above combination for the other.

Apparently the first patent for a multiplex telephone circuit was issued to J. A. Barrett in 1886. This was a system similar to the principles contained in the telegraph circuit above referred to; also the combination could be so arranged that a metallic circuit could be utilized in connection with the ground return and thus form a duplex. Subsequent patents followed, and to date about 28 patents for multiplex telephony have been issued. These cover every conceivable combination and arrangement of circuits in order to produce the desired results, and as is the case in all classes of subjects, there appears the "freak" type and others that while they may not come under the heading of "freaks" are far from being capable of practical application. *Per contra* some of the best engineering talent has contributed to the cause and brought out good designs.

In its simplest form the theoretical design of a multiplex circuit would consist of two metallic circuits of equal length and of the same electrical dimensions, combined through differentially-wound retardation coils so as to form a third circuit; this arrangement is illustrated below. The coil connected across the circuit $A\ B$ is a single core coil with two windings so arranged that connected in series from A to B, the retardation is maximum; whereas connected in parallel ($C\ A$ and $C\ B$) the magnetic effect is nil.



MULTIPLEX TELEPHONY.

It will be seen that current from the telephone M or M' arriving at the point C or C' divides and an equal amount passes to A and to B. The two line wires A and B being of the same potential sign at any particular instant, there is no difference of potential and hence no flow of current from one wire to the other through the telephone O or O'. Under these conditions three conversations may be carried on simultaneously.

To obtain a retardation coil of the proper type it is necessary that the two windings upon one core be wound simultaneously so that the wires are side by side, and that one winding equals the other, both as to ohmic resistance and magnetic effect. As stated before, the line wires of both circuits should bear an equal relation to each other as to length, resistance, leakage and other electrical dimensions. It would furthermore necessitate their being run upon the same poles and situated with respect to each other so as to produce a balanced condition.

While these conditions can be obtained in the laboratory it is difficult for them to be even approximated under commercial conditions, and even if these conditions are established they are liable to be upset by natural causes. From this it will be seen why duplex telephony has as yet not become a prominent factor.

THE BEHAVIOR OF THIN ALUMINIUM FOIL IN ELECTROSTATIC FIELDS.

SOME highly interesting experiments on the behavior of thin aluminium sheets in electrostatic fields are recorded by E. Bandl in a paper recently published in a German physical journal.† These experiments are especially noteworthy because of the analogies they afford with cosmical phenomena.

If a small piece of aluminium foil be introduced between the terminal spheres of a working Wimshurst machine, it will be seen to remain freely suspended in the polar field. In some cases even two or three pieces of aluminium foil can thus be introduced into the field between the poles, when they will float in the air, either independently of one another or clinging together.

* Electrical World.

† Physikalische Zeitschrift, No. 4, 1907.

In this experiment care should be taken to eliminate any disturbing influence of the remaining parts of the apparatus on the conductors of the machine, nor should there be any irregular loss in tension from either of the terminals. In the case of a constant rotation of the machine, the suspended foil will perform some slow motions, and sometimes a slight vibrating will be observed. Rows of sparks connecting the metal foil with one or both terminals will be observed in the dark.

If the operation of the machine be discontinued, the phenomenon will continue without any apparent change for a short time if condensers be inserted in the machine. However, the suspended foil gradually becomes disturbed, commencing to oscillate between the two spheres with increasing speed and amplitude, as long as the condenser charge suffices. After this has been used up, the foil is frequently thrown out of the field, while in other, less frequent cases, it will cling to the sphere.

After the foil has been once thrown out of the field, it may be drawn again into the electric field by starting the machine immediately afterward, there to be fixed in the same way.

Though the above phenomena cannot be perfectly explained, the following considerations might at least partly account for them:

Owing to the "point" effects, the aluminium foil will be alternately charged and discharged by the two spheres, thus being subject to the corresponding forces of attraction or repulsion of the terminals. The metal foil, because of the rapidity of alternation in the direction of charge, performs longitudinal vibrations, the amplitude of which is greatly damped by the relatively high mechanical air resistance. In the case of a sufficiently high electric tension this alternation in direction may become so rapid that the resulting vibrations are not noticed by the eye, owing both to the extremely considerable damping effects and the high frequency. As soon as this state is reached, the foil will appear to remain quite immovable in the electric field.

The above is borne out by the following facts:

If a short piece of a very thin metal thread be introduced between two metal spheres, connected with the terminals of an influence machine and immersed in linseed oil, this thread will show in the electric field a behavior similar to that of the aluminium foil; the vibrations, however, will not be very distinct (possibly because of the greater bulk of the metal wire). If the charge of the spheres exceeds a given limit, a spark discharge will take place in the oil with the intermediary of the suspended metal wire. Immediately before such discharges the above vibration is generally strongest. The effect of the mechanical resistance of the oil is readily recognized from the above.

Any monolateral disturbance in the electrostatic field is apt to disturb the above phenomena. Such disturbances are due probably to the action of the field. Certain hitherto unknown electrostatic pressure effects, however, are likely to play some part in this connection.

If now the metal foil be deformed, e. g., by slightly crushing it between the fingers, the floating phenomena immediately become more complicated, additional components of motion being produced. The most characteristic feature of these phenomena is that the foil in most cases rotates around its axis. So far from being suspended midway between the two terminals, the foil now remains near one of them, more frequently close to the upper segment. The closer this "electric top" approaches the sphere, the more rapid will be the rotation generally. However, in the case of an especially intense working of the machine, the foil frequently rises to a considerable height, without any corresponding loss in the speed of rotation. These phenomena are attended by a strong electric wind emanating from the rotating foil.

Other highly interesting experiments were made with the "electric top." After removing the other terminal sphere as far as possible from the former (connecting it with earth if necessary) so as to constitute a unipolar field, the suspended foil performing the rotation round its axis would execute another motion; in fact, the electric top would migrate along a considerable portion of the surface of the sphere (mostly at some distance from the latter) while tracing the most varied curves. In a dark room these curves could be seen projected as luminous lines on the surface of the polar sphere in question. In fact, the whole of the foil would become luminous, and the most varied figures of rotation, due either to the rotation round the axis or to the secondary motion of the metal foil, would be the more beautiful as the shape of the foil was more complicated.

If the distance traversed by the rotating foil for some reason or other be increased considerably, the whole motion will become irregular, the top migrating from the neighborhood of the poles to the vicinity of the equator of the terminal sphere. This motion can even be controlled to some extent by the aid of some conductor (even a finger). If the metal foil be then maintained for some time close to the equator of the sphere, it begins to turn around the equator or another great circle of the sphere at a moderate speed, and at a considerable distance from the conductor. In the case of such a revolution, the rotation around the axis is either discontinued or slackened.

The author draws attention to the undoubted analogy that exists between these combined rotations and the phenomena of motion in a cosmical planetary or solar system. In both cases we have a central body acting as source of energy and encircled by an-

other body of related substance which sometimes performs a rotation around its axis.

Although these analogies be in no way perfect, they may be sufficient to afford a novel interpretation of certain planetary phenomena and disturbances, such as librations, etc., which are not due immediately to the effect of gravitation.

RADIOACTIVITY AND ATMOSPHERIC ELECTRICITY.

By Prof. H. GEITEL.

AN incomparably greater quantity of energy can be stored in a given mass in the radioactive than in any other form. The explosive energy of mixed hydrogen and oxygen is a million times less than the radioactive energy of radium emanation. Another peculiarity of radioactive energy is that, while it is convertible into other forms of energy it can not (at present, at least) be produced from them. We can not make any substance radioactive by heat or mechnical work, and it is doubtful whether thermal, electrical, chemical, or mechanical impulses even affect the rate at which the energy of radioactive substances is set free.

Hence even the tremendous energy of atmospheric electricity could be furnished by comparatively small quantities of radioactive substances and the supply would be unaffected by the ordinary processes of atmospheric physics.

Air at ordinary temperatures is a very poor conductor of electricity and there is reason to believe that it would be an absolutely perfect insulator if it could be completely shielded from radioactive influences, which always cause electrically charged bodies to lose their charges with greater or less rapidity. It is not believed that the general mass of the air plays any part in this action, which is held to be wholly due to electrified particles called ions, of which half bear positive and half bear negative charges, equal in amount. These ions (which must not be confounded with the ions of electrolytes) are distributed through the air so uniformly that the smallest volume of air that can be separated from the rest will contain equal numbers of positive and negative ions.

But although the positive and negative ions can not be separated mechanically, they can be separated by introducing an electrically charged body. If the body bears a positive charge it repels the positive ions and attracts to itself the negative ions which, if sufficiently numerous, neutralize and destroy the charge. Ions are produced in air by radioactivity and also by cathode rays, ultraviolet rays, elevation of temperature, and certain chemical processes.

It was stated above that air protected from all ionizing influences would probably show not a trace of electric conductivity. This condition is never met in practice. As long as experiments of this sort have been made, a "dissipation of electricity," or gradual loss of charge of electrified bodies in contact with the air, has been observed. This has very generally been attributed to particles of dust, each of which, if attracted and then repelled by the electrified body, would carry off a little of the charge. But the following experiment proves that the ions are the chief agents in the dissipation of charge and that their presence is due, at least in part, to radioactive influences.

An electroscope is placed on a plate of metal which rests on insulating supports. A positive charge is given to the ball, causing the aluminium leaves to diverge, and the electroscope is then covered with a cylinder of wire netting closed at the top. A strong positive or negative charge may be communicated to the cylinder without appreciably affecting the divergence of the aluminium leaves. This is the classical experiment by which Faraday proved that an electrical charge automatically distributes itself over the surface of a conductor in such a manner that the resultant electrical force at any point within the surface is zero.

But although the interior of the cylinder is protected from all electrical influence from without, the dissipation of charge still goes on within and the divergence of the leaves gradually diminishes. When the electroscope and the cylinder are charged alike, either positively or negatively, the electroscope loses its charge much more rapidly than when this charge is of opposite sign to that of the cylinder.

Now, if a small quantity of radioactive matter is placed near the apparatus, this difference becomes so marked that it can be detected in a few seconds. In this case the nature of the process is evident. The ions developed outside the net by the influence of the radioactive substance are separated by the electrical charge of the net. If this is positive it attracts the negative ions. Most of these come into contact with the net and partially destroy its charge, but some of them are drawn through the net into the sphere of action of the electrified ball of the electroscope. If this ball is also charged positively it attracts to itself the ensnared negative ions which speedily destroy its charge, but if the ball is negatively electrified, it repels the negative ions and can only be discharged slowly by the few positive ions that were originally inside the net and by the weak rays that penetrate to it from the radioactive substance outside. The process is the same, *mutatis mutandis*, when the net is negatively electrified.

It appears from this that all the characteristic effects of the air upon charged bodies are greatly increased when the air is ionized by radioactive substances. This fact suggests that air in its usual condition contains ions, and J. Elster and the writer have proved that this is true. In regard to the assumed action of dust in promoting electrical discharge, it is sufficient to cite the observed fact that the charge is dissipated more rapidly in clean than in dusty air. The explanation of this is that the electrified ions attach themselves to the dust particles, the inertia of which retards the subsequent movements of the ions.

At first it seemed absurd to ascribe to radioactivity the origin of the ions always present in air. The radioactive elements, uranium, radium, thorium, and actinium, appeared to be distributed over the earth too sparsely to be the cause of a universal property of the atmosphere. The hypothesis that a small degree of ionization is inseparably connected with the nature of gases, especially atmospheric gases, appeared far more plausible, but this theory has steadily lost ground, although it has not yet been entirely refuted.

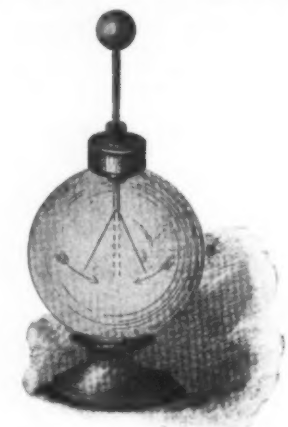


FIG. 1.—OLD STYLE ELECTROSCOPE.

The first step was the discovery of a radioactive "emanation" in the atmosphere. The emission of radiant energy by radium, thorium, and actinium is accompanied by progressive chemical transformations, of which some of the products are radioactive gases called emanations. Radium emanation is in turn transformed into the inactive gas helium, and a radioactive solid, designated as "radium A," which forms an invisible coating on all surfaces in contact with the emanation. This "radium A" attaches itself to the positive ions and can be separated with them from air which contains radium emanation by the action of negatively electrified bodies. It betrays its presence by making the surfaces of such bodies radioactive. "Radium A," however, is very unstable. Rutherford has distinguished five products of its spontaneous transformation and designated them by the letters B, C, D, E, and F. All except radium D are radioactive, not gaseous, and remain attached to the negatively electrified body.

FIG. 2.—ELECTROSCOPE OF ELSTER AND GEITEL.

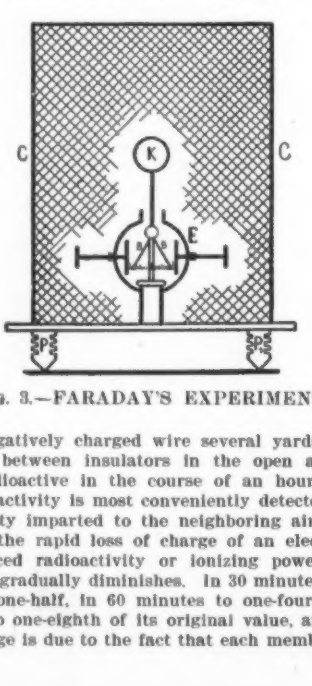


FIG. 3.—FARADAY'S EXPERIMENT.

If a negatively charged wire several yards long is stretched between insulators in the open air it becomes radioactive in the course of an hour or two. The radioactivity is most conveniently detected by the conductivity imparted to the neighboring air as indicated by the rapid loss of charge of an electroscope. The induced radioactivity or ionizing power of the wire then gradually diminishes. In 30 minutes it is reduced to one-half, in 60 minutes to one-fourth, in 90 minutes to one-eighth of its original value, and so on. This change is due to the fact that each member of the series radium A to F is less strongly radioactive than the preceding member from which it has been derived. These invisible radioactive substances can actually be wiped off the wire with a piece of leather which thus becomes radioactive.

These experiments, which have been repeated in many parts of the world, prove that radium emanation is generally diffused through the atmosphere, and consequently that radium itself, the immediate source of the emanation, is present everywhere in or upon the earth. A few ounces of the soil of gardens and fields is found sufficient to ionize air and produce traces of emanation, and it has been estimated that each cubic meter (35.3 cubic feet) of such soil contains 1-10 milligramme (0.00154 grain) of radium. (A layer of soil covering an acre a foot deep would contain two grains of radium.)

But soil is chiefly decomposed rock, and clay is the residue of the very mineral in which radium is found in the primitive rocks. Strutt, indeed, has proved that the proportion of radium in granite and basalt is much smaller than that found in average soil, amounting to only from 1-40 to 1-500 milligramme per cubic meter. These quantities are far smaller than the "traces" of the analytical chemist, yet they radiate a perceptible amount of energy.

Everywhere on earth where experiments have been made, even in the interior of buildings, the radiations of this ubiquitous radium have been detected. We are constantly surrounded and penetrated by them.

The air is ionized to some extent by direct radiation from the ground, but chiefly by the emanation, which is continually formed in the soil and discharged into the atmosphere in consequence of variations in atmospheric pressure, incidentally accumulating in caves and cellars. Hence the ionization of the air remains nearly constant despite the continually occurring unions and mutual annihilation of positive and negative ions.

All the electrical phenomena of the atmosphere can be explained by movements of these ever-present ions, but it is not easy to determine the conditions required to separate the positive and negative ions. The difficulty is partly due to the fact that laboratory experiments must be made with gallons of air, while nature operates with cubic miles.

Let us first consider a comparatively simple phenomenon. In winter a fog often forms at a barometric maximum. It has been known since Volta's time that such a fog is positively electrified. Often the charge is so strong that sparks can be drawn from a wire pendent from a lighted metal lamp placed on an insulating pole. The explanation is that the positive ions of the air, attracted by the negatively electrified ground, are caught in the fog and attach themselves to its component drops which thus become positively electrified. The phenomenon has been reproduced in the laboratory. In the absence of fog the positive ions reach the ground and partly neutralize its always negative charge.

Now let us consider a thunder storm. Every fall of rain, hail, or snow is accompanied by enormous electric tension. If this becomes great enough to strike from cloud to cloud or from cloud to earth, we have a thunder storm. Now, every fall of rain, hail, or snow is caused by the cooling of moisture-laden air below its temperature of saturation or dew-point and this cooling commonly results from the expansion of an ascending mass of air. The apparent mystery of the formation of separate and distinct drops from a uniform mixture of air and water vapor has been explained by two English physicists. Aitkin has discovered that if the air contains dust particles, each of these becomes the nucleus of a drop. The higher a mass of moist air ascends, the more completely will the dust be washed out of it and carried down to earth with the rain. When all the dust has been removed the air can be brought, by further expansion, into a condition of supersaturation, as C. T. R. Wilson has proved. If the air in a glass cylinder is kept saturated by the presence of a little water, the slightest expansion and cooling caused by suddenly retracting a piston produces a fog, so long as dust is present, the fog diminishing in thickness with each repetition of the experiment. After all the dust has been precipitated the air can be brought to supersaturation without the formation of fog by a sudden expansion equal to 1-5 the initial volume, but when the expansion amounts to ¼ fog again appears. A third formation of fog occurs when the expansion becomes equal to 1-3 the initial volume. Wilson has proved that the nuclei of condensation, which in the first fog are particles of dust, are negative ions in the second fog and positive ions in the third fog.*

Let us apply these experimental results to the atmosphere. At a barometric minimum there is an ascending current of air nearly saturated with moisture. A slight reduction of pressure suffices to precipitate some of the water and, with it, some of the dust. At a higher level the ascending air freed of dust becomes supersaturated, but when the supersaturation reaches a certain degree (involving an ascent of more than a mile) there is a second formation of rain drops which carry down with them the negative ions about which they have condensed. Consequently, the air which rises above this level contains an excess of positive ions, but these, too, may be washed down to earth as nuclei of condensation of a third shower. Thus the progressive precipitation of water from an ascending column of air effects a separation of electricities, the work of separation being derived from the energy of the rising air and the falling drop—a source of energy

* SCIENTIFIC AMERICAN SUPPLEMENT, August 25, 1906, p. 25623.

quite sufficient for the electrical phenomena of a thunder storm.

This theory is confirmed by the observed fact that light showers carry, on the average, negative charges, while hail, "cloud bursts," and snow in large flakes, which give independent evidence of rapid condensation from highly supersaturated air, are positively electrified.

Qualitatively, therefore, thunder storms may be accounted for by the ionization of the atmosphere and Gerdien has made it appear very probable that the explanation also suffices quantitatively.

It would be premature to assert that the riddle of the thunder cloud is completely answered. Mixed positive and negative ions have not yet been experimentally separated by condensation. Wilson's experiments were made with artificially produced ions, already separated by electrical methods. But the quantity of electricity contained in a cubic yard of air in the form of ions is very small and a complete separation of the charges is not to be expected. In the free atmosphere, moreover, the establishment of differences of potential would cause movements of the ions and their accumulation on the surfaces of clouds, as in the case of the lowlying fog first cited, which would have a very great influence on the phenomena.

We have seen that the electrical charge of rain water is more often negative than positive. This suggests that the observed invariably negative charge of the earth and the complementary positive charge of the atmosphere may be due to the effect of aqueous condensation on the ions of the air. Here, again, the quantitative relation must decide.

The diffusion of the radioactive emanation from the soil into the atmosphere may also come into play, for Ebert has proved by experiment that emanation-laden and consequently ionized air exhaled from a porous body bears a positive charge and leaves the porous body negatively electrified.

It appears, therefore, that a general explanation of the phenomena of atmospheric electricity can be derived from the observed radio-activity of the soil and ionization of the air. This theory, like its predecessors, is fated to undergo restrictions and corrections, but at least it has the merit of powerfully stimulating the experimental study of atmospheric electricity which has languished since Franklin's time. The facts thus discovered will remain in our possession though the setting which we give them may be changed.—Condensed for the Scientific American Supplement from Umschau.

HOW TO CONSTRUCT A SPEAKING ARC.*

By A. Frederick Collins.

An exceedingly interesting piece of physical apparatus and one that every amateur can make and use provided he has a little knowledge of electricity and a source of direct current at his command, is the speaking arc, or arcophone.

The speaking arc has three features to recommend it, viz.: (*a*) it is an easily constructed device requiring only such materials as may be purchased in the open market; (*b*) the phenomenon involved in its production is as wonderful as it is complicated and is consequently a most interesting study, and (*c*) its usefulness covers a wide range as it can be employed either as a transmitter or as a receiver.

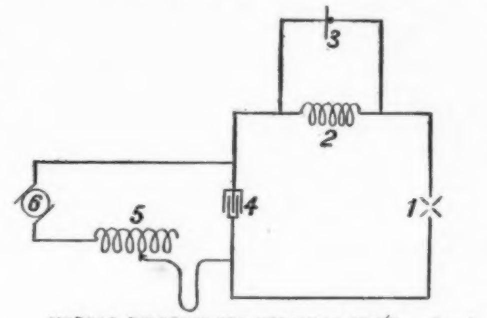
In wireless telephony it can be used with marked advantage as a transmitter for it permits a current of 500 watts to be utilized as against 12 watts with an ordinary telephone transmitter; again in that wonderful instrument known as the telharmonium it acts as a musical receiver and emitter, and finally in ordinary wire telephony it has been employed to send reinforced undulations along the circuit and may in time prove to be the long-looked-for repeater. Doubtless when its properties are more widely known and appreciated it will find many other applications.

In making a speaking arc the chief requirements are a hand-feed arc lamp, a source of direct current, a telephone transmitter, and either an impedance coil or a small transformer coil depending upon the connections used, and a rheostat. In the diagram, Fig. 1, is shown the form most often used and which may be termed the direct connected method. It comprises the arc lamp 1; the impedance coil 2; the transmitter 3; the condenser 4; the rheostat or resistance coils 5, and the source of energy 6.

A hand-feed arc lamp may be purchased as cheaply as it can be made, as many of its parts are cast. Lamps of this type are made in various forms and holding the carbons in different positions; that is, the carbons may be in alinement and set either vertically or horizontally or the carbons may be arranged at right angles to each other. The writer prefers the former type although there is no particular objection to using the angle lamp. Better than a hand-feed lamp an automatic feed lamp of the flaming arc type may be employed to advantage as this circumvents the necessity of constantly adjusting the relative positions of the carbons by hand. Naturally automatic lamps are much more expensive than those controlled by hand.

Whichever make of lamp is chosen it must be trimmed with specially prepared carbons, for in the carbons lies the chief source of success or failure. Solid carbons will not give satisfactory results at all where these form both the positive and negative electrodes, but a solid carbon may be used for the negative electrode if a cored or impregnated carbon is used for the positive electrode.

By the term *cored carbons* is meant carbons having a hole of small diameter longitudinally and axially through them and in which the hole is filled with sodium or other foreign substances so that the arc can be drawn longer than would otherwise be possible. The kind of carbons used in the flaming arc are known as *impregnated carbons* and are made by mixing or mineralizing the carbon with compounds of strontium and magnesium in the proportions of 20 to 70 per cent when a long and brilliant arc can be secured. A full description of impregnated carbons and flaming arc



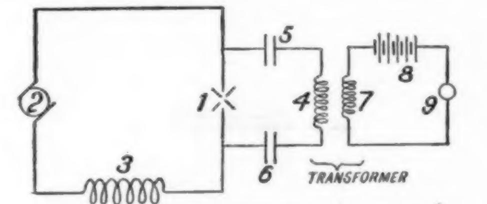
WIRING DIAGRAM FOR SPEAKING ARC (First Form)

Fig. 1.

lamps may be obtained from an article published in the Scientific American July 28, 1906.

Referring now to the diagram, Fig. 1, it will be observed that the lamp with its cored or impregnated carbons is connected in series with the resistance, the impedance coil, and the source of current. The latter may be an ordinary 110-volt direct-current lighting circuit or what is much better, a storage battery, though it is not often such a battery is available unless one is the owner of an electric automobile.

The rheostat may be made up of twelve coils of No. 14 German silver resistance wire, each coil containing eighty turns and each turn having a diameter of three-fourths of an inch. The coils should be stretched on a frame so that the convolutions do not touch each other and the arrangement such that the value of resistance may be varied from zero to its full capacity as circumstances may require. The impedance coil

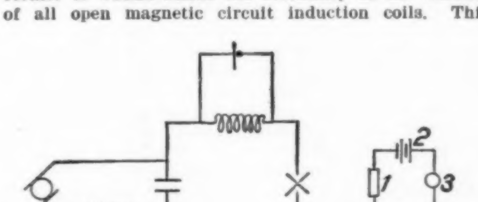


WIRING DIAGRAM FOR SPEAKING ARC (Second Form)

Fig. 2.

may be made by winding sixty turns of No. 14 hard-drawn copper wire on an insulating cylinder four inches in diameter. Shunted around this coil as shown is the telephone transmitter which should be, preferably, of the solid-back type now in common use on ordinary telephone lines and capable of carrying 25 volts and one-half an ampere, while across the main-line circuit is inserted a one-microfarad paper condenser.

Another arrangement of the circuits for superposing the small undulating currents set up by and passing through the transmitter is shown in the diagram, Fig. 2. In this case the arc light 1, the source of current 2, and the variable resistance 3 are in the same relative positions as the first four indicated in Fig. 1. The difference lies in shunting the arc with the secondary coil 4 of a small transformer and the condensers 5 and 6. The primary coil 7 of the transformer is wound inside the secondary in the manner of all open magnetic circuit induction coils. This



SPEAKING ARC CIRCUIT

SELENIUM CELL CIRCUIT

Fig. 3.

transformer may be wound for any ratio of transformation or it may be wound to unity; that is, the wire of which the primary and secondary are formed may be of different sizes as in ordinary induction coils or it may be wound with wire of the same size, with the same number of layers and the same number of turns.

To make a coil of this kind provide a core formed of very soft iron wires ½ inch in diameter and 4 inches long, wind on it four layers of No. 12 insulated magnet wire. This should be well shellacked and then covered with a paper or mica tube, preferably the latter; on this wind the same number of layers and turns of wire for the secondary coil. The terminals of the primary connect with the battery 8 and the telephone transmitter 9, while the secondary is shunted around the arc light as shown. In the primary circuit the battery of dry or other cells giving a voltage equivalent to that required by the transmitter. The condensers in the secondary circuit should have a capacity of one microfarad each.

From the above descriptions and diagrams it will be clear that the speaking arc is not at all complicated in so far as the apparatus is concerned, and that all the parts can be procured at small expense and with little difficulty.

The theory involved in the speaking arc is not nearly as simple as the apparatus required to produce it. For instance in the arrangement shown in the first diagram there are many processes the consecutive effects of which may here be followed out in a more or less elementary manner. To begin with it is well known that when one speaks into a telephone transmitter the sound waves cause the diaphragm to vibrate or move to and fro; this action in turn varies the pressure of the carbon granules interposed in a cylindrical cavity between the diaphragm and the back of the transmitter, these parts being insulated from each other except through the granules, and form the opposite terminals of the circuit.

The variable pressure of the carbon granules modifies the current flowing through the circuit so that the sound waves are changed into electric undulations. In either of the arrangements shown the undulatory current, representing the words spoken, is impressed upon or superposed on the arc light current in the manner shown.

The production of the arc light is of course due to the current flowing through a circuit in which there is a gap formed between the carbon electrodes. Before the current can be made to flow through this gap the ends of the carbons must touch, and as the juncture offers a high resistance the opposed ends are heated to incandescence; at this point if the ends are separated a vapor will be produced between them, and this acts as a conducting path for the current which instead of flowing in a straight line between them takes the form of an arc.

A temperature of 3,000 to 3,500 deg. C. is required to vaporize carbon, and as it is the upper or positive carbon that is vaporized this one should be cored or impregnated in order to produce a greater volume of vapor than is possible with a solid carbon. By increasing or decreasing the current used for supplying the arc, the temperature is naturally raised or lowered and it is quite surprising how very small a change in the value of the current will affect the temperature and therefore the volume of the vapor, and as Duddell has pointed out a current of 1/1,000 of an ampere impressed upon an arc taking 10 amperes will produce a distinctly audible note.

This variation in temperature causes the vapor thrown off by the positive carbon to grow larger or smaller; where these changes in the volume of vapor take place rapidly the eye can detect no change in the arc, owing to the persistency of vision, but if these changes are produced by an interrupted or undulating current the vapor will set up audible sounds due to the temperature causing a sudden expansion and contraction of the air which are in reality sound waves.

Since the variations of the vapor due to the temperature produce the air waves, the strength of the sounds will naturally depend on the volume. To increase the volume of vapor a long arc is needed and hence the value of cored or impregnated carbons. In an arc light formed between solid carbons there is a considerable fall of potential close to the positive carbon, but in an arc produced by cored or impregnated carbons there is a more uniform drop of potential between the positive and negative electrodes. If such carbons are not easily obtainable a hole may be drilled longitudinally through the center of a large solid carbon and a glass rod inserted, the sodium in the glass making it easy to burn an arc an inch or two in length.

The speaking arc besides being employed as a wireless telephone transmitter, a telharmonium receiver, and a telephone repeater may be used as the basis of a large number of exceedingly pretty and instructive experiments. Some of these will necessitate additional apparatus but nearly everything required can be made by anyone who has constructed electrical apparatus.

An experiment that may be mentioned requires a selenium cell 1 in circuit with a dry cell 2 and a telephone receiver 3 as shown in Fig. 3. It was mentioned above that where the variations of the vapor forming the arc are too rapid the eye cannot follow the changes. That these changes exist in the light itself can be demonstrated by projecting a beam on the selenium cell. If, as the vapor fluctuates, the varying light intensities emitted by the arc are permitted to fall on the selenium cell, the changes can be observed by listening to the telephone receiver. By placing the arc-light in the focus of a parabolic mirror and converting it into a speaking search light with the selenium cell in the focus of another parabolic mirror the transmitter and the receiver may be placed several miles apart and articulate speech will thus be transmitted on a beam of light.

Another experiment, in which a Wehnelt electrolytic, a mercury turbine, or a disruptive discharge interrupter is required, produces a curious effect. The interrupter is connected across a 110-volt direct-current circuit, in which the speaking arc is placed. Now,

*Specially prepared for the Scientific American Supplement.

however far the speaking arc may be from the interrupter the former will reproduce the sounds of the make and break nearly as loud as though one were listening to the rhythmical action of the device itself.

A whistling, singing, or musical arc may be made by placing a variable inductance and an adjustable capacity in the shunt circuit instead of the transmitter suggested, and changing the values of these to a suitable degree the arc will give forth a whole octave of notes, thus producing music electrically and without recourse to reeds or strings.

An alternating current can be used as the source of energy for the musical arc but it is not adapted for the reproduction of articulate speech; where an alternating current is used in connection with a telephone transmitter the sound of the voice is intermingled with tones.

To the amateur who possesses a speaking arc there is open an unlimited field of phenomena that is at once new, novel, and flexible in its adaptations, and he may perchance discover some great application for it that will send his name ringing down the halls of time forever.

THE USE OF ALCOHOL AND GASOLINE IN FARM ENGINES.*

By Prof. C. E. Lucke and S. M. Woodward.

SOURCES OF POWER.

There are two great sources of power and an infinitely varied series of mechanical devices and machines for the generation of power. Water power always has been used and probably always will be used so long as the rain falls, but it is insufficient for our present needs or geographically unavailable. The greatest source of power is fuel. Fuels may be divided into two series—those that now exist in the form of natural deposits and those which are being produced continuously. All of the coals, hard and soft, with the lignites and peats, the crude oils and natural gas, exist in the form of deposits; and, while it is true that the decay of vegetable matter may be today forming more deposits of the same nature, it is equally true that we are using the present supply faster than the rate of production. The newest fuel for power purposes is alcohol. This is made from the yearly crops of plants. There is in existence no natural deposit of alcohol, but in a sense it may be said to be possible to produce inexhaustible supplies.

It is only within recent time that engineers have known how to build engines that would produce power from alcohol; and still more recent is the further discovery by engineers that this power can be produced at a cost which may permit its general introduction.

By far the largest part of the power now being used comes from steam produced by the use of coal. This is chiefly due to the fact that as a rule whenever it can be used it is cheaper than possible substitutes, although it is partly due to the fact that steam power is better adapted to some classes of work and is older and better known than power generated by the gas engine in its varied forms. In point of present use, water power stands next to steam in importance. This is largely due to the fact that water power is among the earliest in point of development, but more largely to the fact that it has become possible to transform water power into electrical power, which can be transmitted long distances, and so overcome geographical isolation of the sources.

Next in quantity produced stands power generated by the gas engine. This class of engines includes all machines in which the fuel mixed with air is burned or exploded within the working chambers, whether the fuel be gas produced from coal, natural gas, vapors of any of the mineral oils, vegetable or animal oils, or alcohol. The subordinate position occupied by this source of power is due partly to the fact that engineers have only recently discovered, and are to-day discovering, how best to build these machines and adapt them to the work they are to do. Wind and wave power stand at the foot of the list and always will, so far as quantity of power developed is concerned. This is because of the irregularity of the sources of supply and their comparatively feeble nature.

COMPARATIVE COST OF POWER FROM DIFFERENT SOURCES.

The cost of producing power from any of the above sources is made up of a number of items, including interest on the first cost of the installation, depreciation of the apparatus, its insurance, etc., usually called the "fixed charges." To these should be added the costs of fuel, of labor for attendance, and of repairs, as the principal items, and the cost of lubricants, material for cleaning, and a great many other small miscellaneous items, all going to form what are commonly called "operating charges." In all cases where fuel is used its cost is, if not the most important, certainly a very important item. In the case of water power, where the fuel element is zero, the advantage is offset by an interest charge on the cost of installation for dams, pipes, tunnels, shafts, etc. Assuming that power from all of these different sources is equally well adapted to the particular work to be done and equally available, then that system will be selected for any particular case for which the cost of power is least. Leaving out of consideration water power, it is found that the labor costs do not differ nearly so widely for the different systems, nor are they so large, as the fuel cost. Therefore, the great question to-day in power production as regards immediate cost of power and maintenance is this lowering of the fuel cost.

The cost of fuel per unit of power developed depends, first, on the market price of that fuel at the point where it is to be used, and next, but by no means least, on the ability of the machinery to transform the fuel energy into useful work. If all the different kinds of machinery used for power generation could turn into useful work the same proportion of the energy in the fuel, coal would be almost universally used, because of the present low cost of energy in this form.

COMPARATIVE COST OF ENERGY IN DIFFERENT FUELS.

The different kinds of fuel contain different amounts of energy per pound—that is to say, they have different heating powers. Heat energy is measured in terms of a technical unit called by English-speaking people the "British thermal unit" (B. T. U.). This unit is the amount of heat that will raise the temperature of 1 pound of water 1 degree on the Fahrenheit thermometer. In comparing, therefore, the value of fuels for power purposes there must be taken into consideration two facts—the market price of the fuel and the amount of heat which will be liberated when it is burned. Anthracite coal in the neighborhood of New York can be bought in small sizes in large quantities for power purposes at about $2.50 per ton. This coal will contain about 12,500 B. T. U. per pound. This is equivalent to about 10,000,000 heat units per dollar. Large sizes, such as egg coal, containing about 14,000 B. T. U. per pound, can be bought in large quantities for about $6.25 per ton, which is equivalent to 4,500,000 B. T. U. per dollar. Other grades of anthracite coal and the various grades and qualities of bituminous coal will lie between these two limits of cost. Illuminating gas in New York costs $1 per 1,000 cubic feet, which is equivalent to about 500,000 heat units per dollar. Natural gas in the Middle States is sold for 10 cents per 1,000 cubic feet and upward. This fuel at the minimum price will furnish about 10,000,000 heat units for a dollar. Crude oil sells in the East at a minimum price of 4 cents per gallon, which is equivalent to about 4,000,000 heat units per dollar. Gasoline sells at a minimum price of 10 cents per gallon, which is equivalent to about 1,200,000 heat units per dollar. Kerosene sells from 10 to 30 cents per gallon, which is equivalent to 1,200,000 and 400,000 heat units per dollar, respectively. Grain alcohol, such as will be freed from tax under the recent legislation, will sell for an unknown price; but for the purpose of comparison, assuming 30 cents per gallon as a minimum, it will give 270,000 heat units per dollar. Gasoline, kerosene, crude oils, and, in fact, all of the distillates have about the same amount of heat per pound; therefore, at the same price per gallon, ignoring the slight difference in density, they would deliver to the consumer about the same amount of heat per dollar, whereas the other liquid fuel, alcohol, if sold at an equal price, would give the consumer only about three-fifths the amount of heat for the same money. From the figures above given it appears that the cost of heat energy contained in the above fuels, at the fair market prices given, varies widely, lying between 200,000 heat units per dollar and 10,000,000 heat units per dollar. It is possible to buy eight times as much energy for a given amount of money in the form of cheap coal as in the form of low-priced gasoline, or twenty-five times as much as in the form of high-priced gasoline or kerosene. This being true, it might seem to a casual observer as rather strange that gasoline should be used at all, and the fact that it is used in competition with fuel of one-eighth to one-twenty-fifth its cost shows clearly that either the gasoline engine has some characteristics not possessed by an engine or plant using coal, which makes it able to do things the other can not do, or that more of the heat it contains can be transformed into energy for useful work. Both of these things are true.

THERMAL EFFICIENCY.

As was pointed out before, the different kinds of machinery used to generate power render more or less of the fuel energy into useful work; all systems do not give equal returns for equal amounts of heat supplied. If all the heat energy in fuel were transformed into work with no losses whatever in the mechanism, the machinery would be said to have a thermal efficiency of 100 per cent, and it would require 2,545 heat units per hour to maintain an output of 1 horsepower. If half of the energy in the fuel were lost in the machinery, its thermal efficiency would be said to be 50 per cent, and there would be required 5,090 heat units per hour. If only 1 per cent of the heat energy in the fuel were transformed into useful work, the efficiency of the machinery or power plant would be said to be 1 per cent, and there would be required 254,500 heat units per hour to maintain 1 horse-power.

Steam plants in use represent a great variety of styles or types, but in general it may be said that the more complicated and refined the plant and the larger its size the more efficient it is, because the complication exists only as evidence of an attempt to minimize the losses of heat in the machinery. Similarly the more steadily the plant works at the output for which it was designed the higher the efficiency of the plant, and conversely, the smaller the plant, the simpler the apparatus, or the more intermittently it works, the lower its efficiency. Steam-power plants are built today to do every conceivable sort of work, and range in size from 1 horse-power to 100,000 horse-power. For purposes of comparison neither the largest nor the smallest should be used, nor the best performance nor the worst performance of these plants, but a figure representing a fair average for the conditions named should be taken. Large steam plants in their daily work seldom use less than 2 pounds of poor coal per hour for each useful horse-power (known as a brake horse-power), which is equivalent to about 25,000 B. T. U. per hour, and which corresponds to about 10 per cent thermal efficiency. Small steam plants working intermittently, such as hoisting engines, may use as high as 7 pounds of coal per brake horse-power, which is equivalent to about 100,000 heat units per brake horse-power hour, or 2.5 per cent thermal efficiency. Some plants will do better than the above with proper conditions, and some may do worse, but in general it may be said that the performances of steam plants lie between the limits of 2.5 and 10 per cent thermal efficiency.

Plants consisting of gas producers for transforming coal into gas for use in gas engines have in general a much higher thermal efficiency than steam plants doing the same work. They are, however, not built quite so small as steam plants, the smallest being about 25 horse-power, and in general they have not been built so large, the largest being only a few thousand horse-power. Their efficiency, however, does not vary so much as is the case with steam plants. It may be fair to say that under the same conditions as above outlined these plants will use 1¼ to 2 pounds of coal of fair or poor quality per brake horse-power hour, which gives a thermal efficiency ranging from 18 to 10 per cent. These plants can be made to do much better than this, and perhaps may do worse, although the variation is not nearly so great as for steam plants.

Gas engines operating on natural gas or on illuminating gas from city mains will, on fluctuation of load with the regular work, average about 12,000 heat units per brake horse-power hour, or 20 per cent thermal efficiency. Exploding engines operating on crude oil will average about 25,000 heat units per brake horse-power hour, which is equivalent to about 10 per cent thermal efficiency. Exploding engines using gasoline should operate at a thermal efficiency of about 19 per cent under similar operating conditions.

The efficiency of an alcohol engine may be assumed at this time to be unknown, but as alcohol can be burned in engines designed for gasoline, it may be assumed that such an engine will have with alcohol fuel the same thermal efficiency as with gasoline, to wit, 19 per cent for fair working conditions.

From the above brief discussion of the efficiency of different methods of power generation from different fuels it appears that quite a range is possible, though not so great a range as exists in the case of cost of fuel energy. Efficiency is seen to lie somewhere between 2½ and 20 per cent for all the fuels under working conditions. It is known that actual thermal efficiency under bad conditions may be less than 1 per cent and under the best conditions as high as 40 per cent, but these are rare and unusual cases. The range given is sufficient to indicate that a highly efficient method may make the fuel cost per unit of power less with quite expensive fuel than it would be with cheaper fuel used in a less efficient machine. It is also perfectly clear that without proper information on the efficiency of the machine or the efficiency of the plant it is impossible to tell what the cost of fuel per horse-power hour will be, even though the price of the fuel per ton or per gallon be known. From the figures given on the cost of fuel and a fair average for plant efficiency the cost of fuel per horse-power hour is computed as given in the tables opposite.

ADAPTABILITY OF VARIOUS TYPES OF ENGINES.

The tables show very clearly that the cost for fuel to maintain a brake horse-power for one hour varies widely, and at the prices given the dearest costs nearly 48 times as much as the cheapest. The fact that not everybody uses the fuel giving the cheapest power in point of fuel cost, but that even the most expensive finds a ready market, makes it clear that there must be good reasons. These reasons may be found in local variations in price of fuel, in differences in adaptability of the engines to the work required, and in the fact that the above figures show fuel cost only, whereas there are great differences in the cost of attendance. An elaborate steam plant, to be even fairly efficient, must be continuously operated at fairly heavy load; intermittent working or working at a decreased output makes them wasteful of fuel. Moreover, the apparatus is so complicated, slow to start up, and dangerous to life and property in careless or inexperienced hands that persons must become skilled by years of study and practice before they may be allowed the handling.

The gas engine with its producer can handle to-day the same kind of coal that is used in steam plants, and yet the weight of this apparatus and its lack of flexibility, compared with steam engines, make it unavailable for steamships and locomotives; so it is clear again that adaptability to service is even more important than the cost of fuel. Similarly, gas-producer plants have not yet been successful for sizes smaller than 25 horse-power, and especially unsuccessful have they been so far for intermittent work. For the small sizes the steam plant is also very wasteful of fuel, requires a skilled operator, and is slow in starting; so it is clear why engines burning crude oil, gasoline, kerosene, and other liquid fuels explosively should be used for light work in isolated situations where the work is intermittent and where quick starting and small care in attendance are essential. In this connection it must not be forgotten that a kerosene, gasoline, or crude-oil engine can be started in a few minutes and can even be left running for practically a whole day with only an occasional examination to see that the oil cups are flowing properly and the bearings are not getting hot through being dirty. Steam engines with their boilers, on the contrary, can not be started inside of one or two hours, and all the fuel

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necessary to raise steam is wasted so far as the work to be done is concerned. Moreover, a steam engine requires continuous feeding of coal and close attention, so that a man must be always near it, having no other duties but its care.

In the natural-gas regions a large number of gas engines are working, and in the oil regions a similar number of oil engines and gasoline engines, because the nearness to the supply makes the fuel cheaper than transported fuel, and the exploding engine is more efficient than the steam engine.

It thus appears that in spite of the fact that the fuel element in the cost of power is high for engines burning crude oil, kerosene, and gasoline in comparison with those using coal, at the same time they possess advantages that do not exist in steam plants and gas-producer plants, which give them a very distinct field, as indicated by the following uses to which these engines are being put to-day: Driving boats, automobiles, and railroad motor cars; pumping water for private houses, for farms, for irrigation, and in some cases for municipal service in small towns; compressing air for drilling, hoisting, riveting, etc.; operating small carpenter shops, machine shops, forge shops, and, in fact, any kind of small shop; operating ventilating fans in buildings and in mines; running small factories, such as creameries and butter factories; operating feed-cutting and grinding machinery, corn shredders, and threshing machines; operating other special machines, such as ice-cream freezers, printing presses, mostly small in size, and making electric light in isolated localities. Not only is this field a real one, but it is a large one, as is shown by the number of these small engines being sold to-day. The exact figures on the sales are not available and it is impossible to secure them because of the unwillingness of manufacturers to tell their business; but when a single manufacturer (as is the case) is selling 425 per day, and there are in the United States alone some 300 manufacturers of importance, there can be no doubt as to the popularity of these machines.

Cost of energy in fuels.

Kind of fuel.	Cost of fuel.	British thermal units (B. T. U.).	Number of B. T. U. bought for $1.
Small anthracite	$2.50 per ton	12,500 per pound	10,000,000
Large anthracite	6.25 per ton	14,000 per pound	4,500,000
Illuminating gas	1.00 per 1,000 cubic feet	550 per cubic foot	550,000
Natural gas	.10 per 1,000 cubic feet	1,000 per cubic foot	10,000,000
Crude oil	.04 per gallon	20,000 per pound	3,650,000
Kerosene	.10 per gallon	20,000 per pound	1,200,000
Do	.30 per gallon	20,000 per pound	400,000
Gasoline	.10 per gallon	20,000 per pound	1,200,000
Do	.30 per gallon	20,000 per pound	400,000
Grain alcohol	.30 per gallon	12,000 per pound	270,000
Do	.40 per gallon	12,000 per pound	200,000

Fuel cost of power.

Fuel and type of plant.	Fuel required per horsepower per hour.	British thermal units required per horsepower hour.	Thermal efficiency.	Cost of fuel.	Cost of fuel per horse-power per hour.
Anthracite coal:			*Per cent.*		*Cents.*
Large steam plant	2 pounds	25,000	10	$2.50 per ton	0.25
Do	2 pounds	25,000	10	6.25 per ton	.57
Small steam plant	7 pounds	100,000	2½	2.50 per ton	1.00
Do	7 pounds	100,000	2½	6.25 per ton	2.20
Producer gas plant	1¼ pounds	14,000	18	2.50 per ton	.14
Do	1¼ pounds	14,000	18	6.25 per ton	.31
Do	2 pounds	25,000	10	2.50 per ton	.25
Do	2 pounds	25,000	10	6.25 per ton	.57
Illuminating gas	24 cubic feet	12,000	20	1.00 per 1,000 cubic feet	2.20
Crude oil	1.4 pints	25,000	10	.04 per gallon	.68
Gasoline	1.1 pints	13,400	19	.15 per gallon	1.70
Do	1.1 pints	13,400	19	.30 per gallon	3.40
Alcohol			[a]19	.30 per gallon	5.00
Do			[a]19	.40 per gallon	6.70

[a] Efficiency of alcohol is assumed to be the same as that of gasoline for identical conditions of use.

Alcohol at a price unknown now becomes available for use in engines, whose peculiarities are not fully known and whose ability to transform heat into work is correspondingly in question. If the alcohol engine can be shown to have an efficiency as high or higher than other liquid-fuel engines and be similar in type and characteristics, it can do all that they can do, and its field will be the same as their field in spite of fuel cost; but by field is meant the nature of the work rather than the geographical location. It is likely that the alcohol engine will find as favorable a geographical location as the natural-gas engine and the oil engine have near the source of supply and far from the source of competing supply. But should it appear that the alcohol engine can do more or better work than its oil or gasoline competitors, its field will be wider. In any case the position which the alcohol engine may take to-day is no criterion as to its future, because it will operate on a source of energy or fuel supply which, as pointed out, is inexhaustible, whereas the supply of both crude oil and its distillates may ultimately become exhausted.

The determination, then, of the position of the alcohol engine to-day involves a forecast of the future, and should it be shown to be able to compete now it must inevitably reach a stronger and more important industrial position as time goes on. This is the fact that has led governments to take up the question, and among them the United States is the latest.

FIRST USE OF ALCOHOL ENGINES.

About the year 1876 there was placed on the American market the first successful internal-combustion engine using petroleum distillate. This engine was invented by George Brayton. Following the attempt of Brayton to use petroleum distillate came a series of inventions improving this class of engine, lasting for about twenty years, when the modern forms of kerosene, gasoline, and crude-oil engines may be said to have been developed. During this time the subject of alcohol as fuel in engines seems to have been either not thought of at all or not given any attention. The first serious attempt to examine into the possibility of alcohol as a fuel in competition with petroleum and its distillates seems to have been made in the year 1894 in Leipzig, Germany, by Prof. Hartmann for the Deutschen Landwirtschafts-Gesellschaft. The engine used was built by Grobb, of Leipzig, to operate on kerosene, and used 425 grammes of kerosene per hour per brake horse-power, which is equivalent to 0.935 pound, or 1.1 pints, approximately. This indicates for the kerosene a thermal efficiency of 13.6 per cent. When operating on alcohol the engine used about twice as much, or 839 grammes, which with this kind of alcohol was equivalent to a thermal efficiency of 12.2 per cent, or a little less than with kerosene. This experiment would seem to indicate that, compared with kerosene, alcohol, as a fuel, offered very little chance for successful competition. In spite of this, however, very vigorous efforts were made to develop an alcohol engine that would be better than this one, and thus was inaugurated a remarkable series of experiments, congresses, and exhibitions with the one end in view—of stimulating the production of the best possible alcohol motor.

The first stimulus was given by the German alcohol distillers, who sought to enlarge their market. They succeeded in interesting the German government in the question by enlarging on the national significance of having available a source of fuel for power, inexhaustible in quantity, to be produced within the national domain from the yearly crops. Under the double stimulus of government assistance and the desire of the distillers to increase their output, inventors and manufacturers were induced to spend their time and money with a resulting decided improvement in the motor. An engine built by Körting Brothers, of Hanover, fitted with a vaporizer invented by Petreano, tested at the Polytechnic School at Charlottenburg by Prof. Slaby showed a consumption of 550 grammes of 86.2 per cent alcohol by weight, which is equivalent to 1.21 pound, or 1.4 pint, or a thermal efficiency of 17.5 per cent. This result showed an advance of nearly 50 per cent in thermal efficiency over the Grobb engine tested a year or so earlier by Prof. Hartmann. Following this improvement there resulted a continual development of the alcohol motor, interest in which was kept up by exhibitions in which prizes were offered and by scientific societies. The most important of these are given below:

Exhibition at Halle-on-Saal, Germany, June 13-18, 1901.

Exhibition (national) at Paris, France, November 16-24, 1901.

Exhibition at Berlin, Germany, February 8-16, 1902.

Exhibition (international) at Paris, France, May 24-June 1, 1902.

Exhibition at Madrid, Spain, late in the year 1902.

Congress at Montpellier, October 11-21, 1902.

Congress at Paris, France, March 11-17, 1902.

Exhibition (international) at Vienna, Austria, April 2-June 12, 1904.

Exhibition at Rome, Italy, February 6-16, 1904.

Besides the above named, there were many others of lesser importance, all contributing to the rapid development of this class of machine.

The results of this development may be summed up by saying that the thermal efficiency of the motor was raised to something over 30 per cent, which is quite a remarkable showing in comparison with the original figure of 12.2 per cent in 1894. It must be clearly understood, however, in interpreting these figures that they are the best possible attainable at the time reported. They indicate, so far as the fuel costs are concerned, that with a motor specially constructed for alcohol the fuel prices per gallon might be twice as much for alcohol as for petroleum distillate and still give power for less money, assuming that attendance, repairs, lubrication, etc., cost no more in the case of the alcohol engine.

The Office of Experiment Stations of this Department, in connection with its Irrigation and Drainage Investigations, has tested a number of different types of gasoline engines with alcohol and obtained figures which show the comparative consumption of gasoline and alcohol in the same engine. The detailed results of these tests will be published in a technical bulletin, but the general results may be given here. The first tests were made without any particular attempt at obtaining the best adjustment of the engine for each fuel, and showed a consumption of alcohol two to three times as great by weight per horse-power hour as was necessary with gasoline or kerosene. These figures indicate the necessity or desirability of determining the proper conditions of adjustment, because these were found to have a serious influence on the amount of fuel consumed. With care in adjusting the engine so as to secure the most economical use of the alcohol, it was found that, under like conditions, a small engine consumed 1.23 pounds of alcohol to 0.69 pound of gasoline per brake horse-power hour—that is to say, with the best adjustment of the engine for each fuel there was required 1.8 times as much alcohol by weight as gasoline per brake horse-power hour. It was also shown in making this adjustment that it was possible to burn more than twice as much alcohol as stated, by improper adjustments, and still have the engine working in an apparently satisfactory way. The range of excess gasoline which might be burned without interfering seriously with the working of the engine was not so great, being a little less than twice as much as the minimum. These early experiments, therefore, confirmed the early results secured in Germany, to wit, that an engine built for gasoline or kerosene will, when unchanged, require about twice as much alcohol by weight for the same work; but they also indicate something that is not pointed out by the reports sent us from abroad—that is, the great importance of securing the best adjustment of the machine.

To understand why this adjustment of the machine can have such a serious effect and at the same time understand why exploitation and study were successful abroad in raising the efficiency of the alcohol engine from 12.2 to over 30 per cent in five or six years requires a knowledge of technology. The reasons can only become clear to one understanding the mechanism of these engines and to one familiar with the chemistry of the fuels and the physical theories of explosive combustion.

(To be continued.)

[Concluded from Supplement No. 1633, page 26160.]

RATE OF RECESSION OF NIAGARA FALLS.—II.

By G. K. Gilbert.

THE AMERICAN FALL.

The recession of the American Fall is much slower than that of the Horseshoe. The sheet of water on its brink is comparatively thin, and the force the water acquires in falling is not sufficient to remove the larger of the limestone blocks broken from the ledge above. The blocks are therefore heaped at the base of the cliff and serve as a natural riprap to protect the shale against wear. (See Figs 18 and 19.) Since the Horseshoe Fall parted from the American, leaving it stranded at the side of the gorge, there has evidently been some falling away of the crest of the American Fall, else there would be no limestone blocks at its base. But as the talus increases in height it becomes more and more protective, and the rate of recession should theoretically diminish.

It has already been observed that the geologist's interest in the rate of recession applies primarily to the Horseshoe Fall, because the work of that fall makes the gorge longer. If the conditions of erosion had been uniform during the whole period of the excavation of the gorge the work of the American Fall would have little bearing on its time estimates, but the volume of the river has not always been so great as at present, and there were two epochs in the history of the gorge when the volume was very small. During those epochs the discharge of the whole river was probably not much greater than the present discharge through the American channel, so that the conditions affecting erosion were somewhat similar to those illustrated by the American Fall. For this reason it is worth while to inquire at what rate the American Fall has receded since the first precise observations on its position and contour.

Traditional information as to changes in the American Fall is summarized by Lyell:

"The sudden descent of huge rocky fragments of the undermined limestone at the Horseshoe Fall, in 1828, and another at the American Fall, in 1818, are said to have shaken the adjacent country like an earthquake. According to the statement of our guide in 1841, Samuel Hooker, an indentation of about forty feet has been produced in the middle of the ledge of limestone at the lesser fall since the year 1815, so that it has begun to assume the shape of a crescent, while within the same period the Horseshoe Fall has been altered so as less to deserve its name."

The graphic record begins with two camera lucida

sketches by Basil Hall, made in 1827. One was from Goat Island, near the southern end of the crest line, the other from a point on the American shore near the northern end of the crest line. His view points were so near to the fall that he was able to represent details too small to appear in the sketch of the Horseshoe Fall. The American Fall was also mapped with the same care as the Horseshoe in 1842, 1875, 1886, 1890, and 1905. Since the time of the daguerreotype the fall has been photographed from positions similar to those occupied by Basil Hall, and in 1895 I recovered his view points as nearly as practicable for the

FIG. 10.—AMERICAN FALL IN 1827.

Copy of sketch by Capt. Basil Hall, made with camera lucida, from Goat Island. For explanation of broken line *A* see next page.

FIG. 11.—AMERICAN FALL IN 1895.

Photograph from balcony just above view point of Fig. 10.

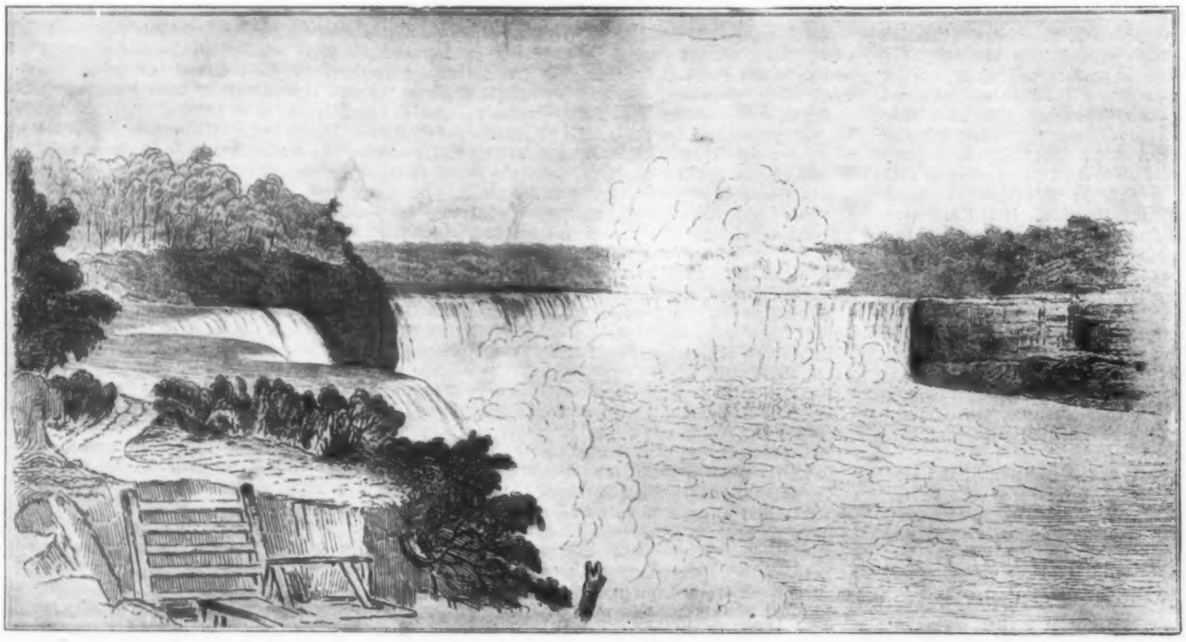


FIG. 12.—AMERICAN FALL IN 1827.

Copy of sketch by Capt. Basil Hall, with camera lucida, from American shore. The Horseshoe Fall is in the distance.

THE RATE OF RECESSION OF NIAGARA FALLS.

sake of making photographs which might be compared with his camera-lucida sketches. To this end I visited the localities with his sketches in hand, and endeavored to determine the view points by comparing various details of the sketches with the landscape before me. His sketches and the photographs are compared in Figs. 10, 11, 12, and 13.

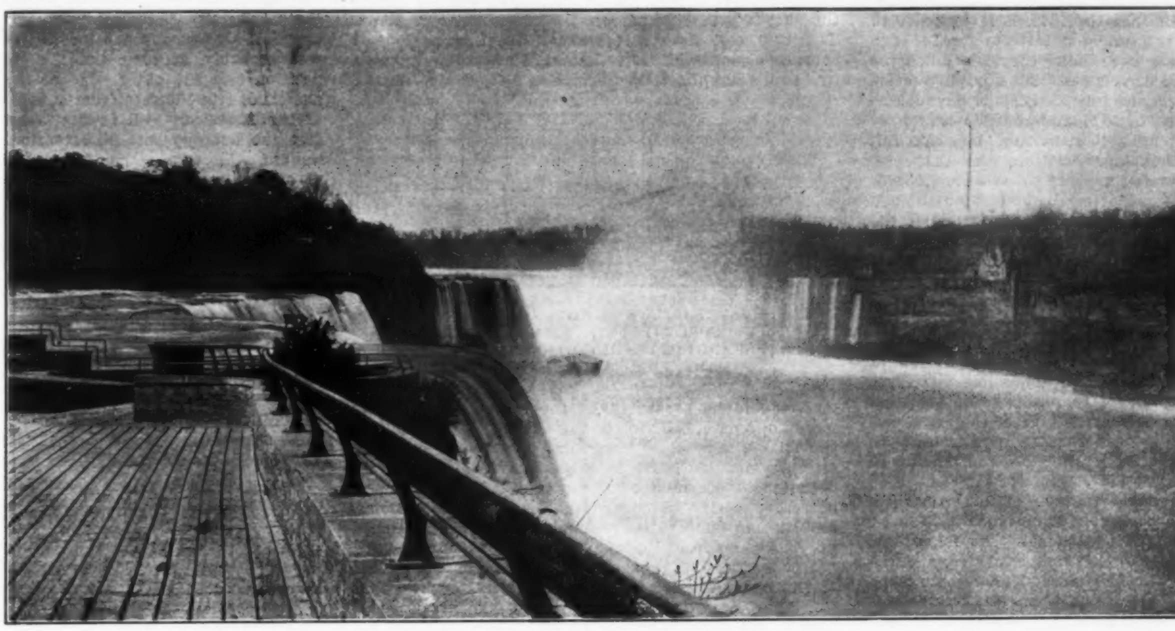


FIG. 13.—AMERICAN FALL IN 1895.

Photograph from Prospect Point, a few feet to the left of the view point of Fig. 12. Note that the American Fall has changed little and the Horseshoe Fall much.

Examination of the combined map (Fig. 4) shows that the outlines recorded in 1875, 1886, 1890, and 1905 run closely together, the plotted lines intersecting one another at various points, while the line of 1842 coincides for only a part of the distance. A broad projection near the northern shore is indicated by the map of 1842 only, and that map also gives a more advanced position for the middle part of the crest line.

There is good reason to question the accuracy of the map of 1842, especially in the vicinity of the northern shore. The area there indicated outside the line of 1875 and later maps is 110 feet broad. As its position is close to Prospect Point, which has been a popular view point through the entire period under consideration, the falling away of such a body of rock, either gradually or all at once, could not have escaped notice, but (so far as my reading goes) current literature, including the literature of the guidebooks, is silent in regard to it. In addition to this negative evidence, there is positive information in the Basil Hall sketches. Comparing his sketch from Goat Island (Fig. 10) with my photograph made from approximately the same point in 1895 (Fig. 11) it will be seen that there is essential correspondence in the distant headlands along the river. By means of these headlands I was enabled not only to establish a definite relation between the two views, but also to correlate the sketch of 1827 with the map of the gorge made in 1875, and by the aid of that map with the various charts of the crest line. Through these comparisons it is shown that if the crest line in 1827 had had the form indicated by the map of 1842, its profile would have the position indicated by the dotted line A in Fig. 10, and the cataract would conceal the eastern half of the gorge vista. If the great salient did not exist in 1827, it could not have existed in 1842. The

FIG. 16.—THE AMERICAN FALL IN 1854 OR 1855.

From a daguerreotype. To be compared with Figs. 12 and 13, but the view point is farther to the left and nearer the water. Many details of the crest of the American Fall are the same as in 1895, but the details of the Horseshoe Fall and the cliff profile of Goat Island differ from those of 1827 and 1895.

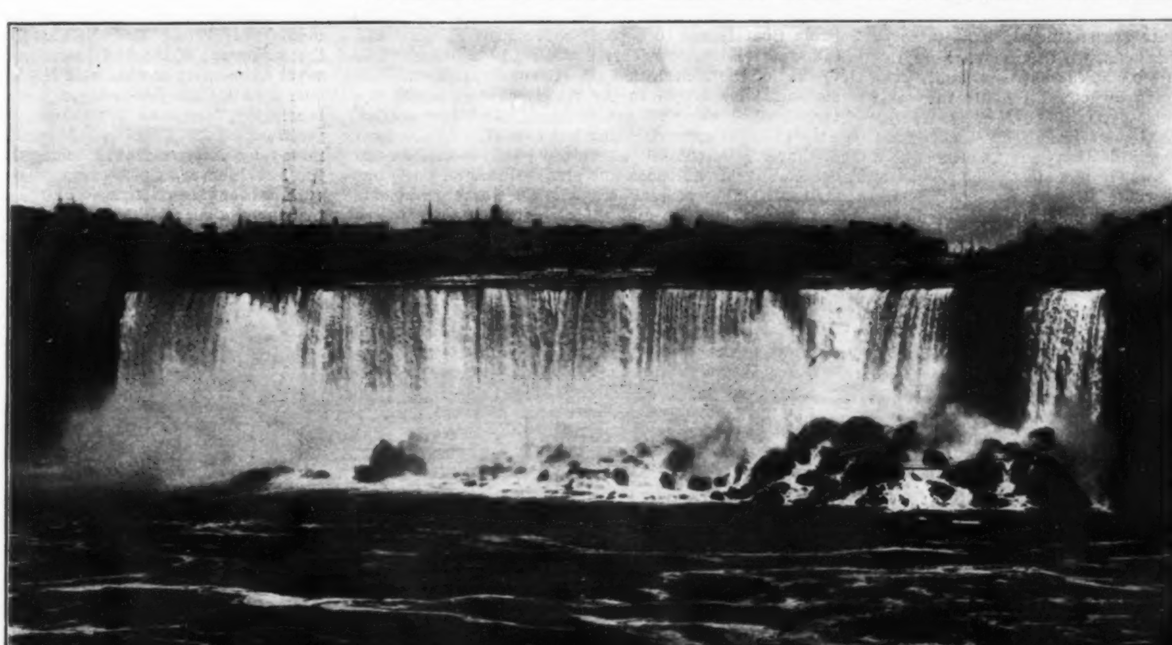


FIG. 18.—AMERICAN FALL ABOUT 1885.

Shows talus of limestone blocks. Compare with Fig. 19, which represents the middle part of the fall.

THE RATE OF RECESSION OF NIAGARA FALLS.

conclusion appears unavoidable that the map of 1842 is wholly erroneous in its delineation of that part of the crest line near Prospect Point.

As the Basil Hall sketches have thus served to discredit a portion of the map of 1842, it is in order to inquire whether they afford a substitute for the evidence ruled out. Once more using the vista down the gorge as the basis of correlation, and applying measurement to points recognized as identical, I have ascertained that the sketch of 1827 and the photograph of 1895 give to the extreme salient of the American Fall almost identically the same position. At that particular point the recession appears to be zero. Nearer than the salient, and appearing about one-fourth inch to the right of it, is a peculiar configuration of the crest line which seems to be common to the two views. In the photograph a dark wedge projects obliquely downward and toward the left, interrupting the body of white. In the sketch its position is occupied by a sweeping curve, less angular than the other lines representing the turn of the water. Making proper allowance for the fact that the water was unusually low in the summer of 1895, I think it quite possible that these features of the two pictures represent the same local and peculiar configuration of the rock of the crest, and the suggestion they give is that there has been no change whatever in the crest line of that portion of the American Fall since 1827.

The earliest good daguerreotype of the American Fall to which I have been able to assign a date is reproduced in Fig. 16. The gentleman who loaned me the daguerreotype appears in the picture as a child, and was able by that circumstance to fortify his memory and say that the view was taken in 1854 or 1855. Close comparison of the daguerreotype with the photograph reproduced in Fig. 13, shows a large number of identical details ranged along the crest from the deepest re-entrant to Luna Island, and proves that there

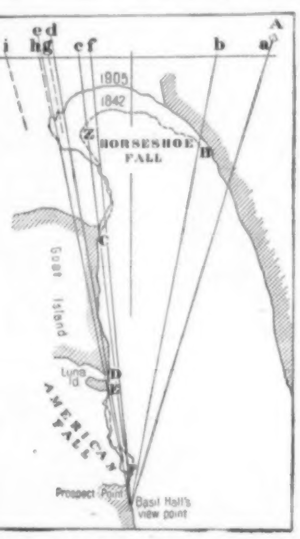


FIG. 15.—MAP OF NIAGARA FALLS, WITH LINES DRAWN TO VARIOUS POINTS FROM THE POINT OCCUPIED BY BASIL HALL IN MAKING A CAMERA LUCIDA SKETCH. COMPARE FIGS. 12, 14 AND 17.

A, Forsyth's hotel; B, western edge of Horseshoe Fall; C, profile of Goat Island cliff; D, crest of American Fall at Goat Island; E, crest of American Fall at Luna Island; F, extreme salient on crest of American Fall.

was practically no recession in that part of the American Fall in the forty years from 1855 to 1895.

In Basil Hall's view from the American shore (Fig. 12) a number of points are sufficiently definite to be used in correlating the sketch with the map. Forsyth's Hotel appears on the bluff at the extreme right. The western edge of the Horseshoe Fall holds the same position as in 1842. The eastern edge of the Horseshoe Fall, or the right-hand profile of Goat Island, serves as another identification point, although it has doubtless fallen away a few feet. The crest of the American Fall where it adjoins Goat Island and its interruption by Luna Island are somewhat indefinite objects by reason of the curvature of the water profile, but are nevertheless serviceable, especially as their stability is assured by the general agreement of records. The nearer profile of the American Fall is assumed on the evidence just cited to have the position assigned it by the maps of 1890 and 1905. These points all appear on the map (Fig. 4). The approximate position of the artist's view point is suggested by the foreground, taken in connection with various allusions in the literature.

As the geometric method of making comparison between a picture and a map may not be familiar to all readers of this paper, I venture to explain the procedure in this case, adding that similar methods were employed in other comparisons to which allusion has already been made. It is evident that the distance of any object in the view, Fig. 14, to the right or left of a central vertical line depends on the horizontal direction of the object from the viewpoint. In order to show clearly the relations of the directions of the various objects, I drew from them a series of vertical lines by which their positions were projected against a horizontal line near the top of the sketch. Lines were also drawn on the map, Fig. 15, from the assumed view point to the corresponding objects, and an additional line was drawn in the general direction corresponding to the middle of the picture. Then at right angles to the last-mentioned line, and at a suitable distance ascertained by trial, a line was drawn intersecting all the direction lines. The map gives the projection of the various points on a horizontal plane; the sketch gives their projection on a vertical plane. The line last drawn represents the intersection of these two planes of projection. If the map and sketch are both accurate, then the points *a*, *b*, *c*, etc., on the

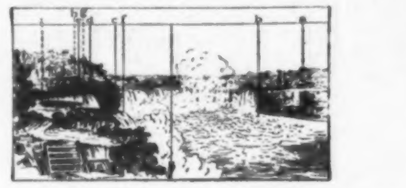


FIG. 14.—BASIL HALL'S SKETCH OF AMERICAN FALL FROM PROSPECT POINT, WITH LINES USED IN TRANSFERRING ITS DIRECTION TO MAP. COMPARE FIGS. 12, 13, 15 AND 16.

map should be separated by the same spaces as the points *a*, *b*, *c*, etc., at top of the sketch. As a result of the trial a very close agreement was found—as close an agreement as could be expected in view of the indefiniteness of some of the points. This agreement serves to verify the determination of the viewpoint, and also to support the conclusion that the criticism previously made of the map of 1842 is valid.

Having thus established the relation of the sketch to the map, it was possible to transfer the directions of other points of the sketch to the map. Two re-entrants and one salient of the fall were projected upward on the sketch, giving the points *g*, *h*, and *i*. These were transferred to the line on the map representing the intersection of projections, and lines were drawn from them to the viewpoint. These last-mentioned lines indicate on the map the directions of the corresponding features as recorded by the sketch of 1827, but do not show their distances from the viewpoint. They do not fix on the map the positions of the salient and re-entrants, but assign certain limits to be observed in any attempt to chart the crest line as it was in 1827. They are represented on a larger scale in Fig. 17. In a general way they indicate that there has been a small amount of recession since 1827 in various parts of the crest line. Such an inference, however, should not be made without qualification, because the indicated amount of recession is of the same order of magnitude as the errors of survey and other imperfections of the data.

To give the matter quantitative statement I have tried the experiment of assuming as correct the map of 1905 and the limitations inferred from the sketches of 1827, and then interpreting other data in such way as to afford the greatest plausible recession. A computation based on these assumptions gives an average total recession since 1827 of 19.7 feet and an average annual recession of 0.25 foot. This I regard as a maximum estimate. It is highly probable that the actual average rate of recession is less than this, and it may be much less. The idea that it is much less finds support in the identical appearance of one part of the crest in 1855 and 1905, and in the apparent identity of another part in 1827 and 1895.

The matter can be approached in another way. The distance through which the Horseshoe Fall has retreated since it parted from the American Fall is about 2,500 feet. Allowing 5 feet per annum as the rate of recession, the parting took place about five hundred years ago. The condition of the American Fall at the time of separation may be inferred in a general way from an examination of the eastern part of the Horseshoe Fall at the present time (Fig. 9). From Goat Island to a point about 500 feet westward the water is shallow, corresponding in average depth to that of the American Fall. Beyond that point it is comparatively deep. In the region of deep water the recession of the cataract is rapid, and the portion with shallow water is being left behind. At the base of that part of the fall where the water is shallow the descending stream does not plunge into the pool, but strikes a talus of rock fragments. These fragments are in part visible, and their existence is elsewhere inferred from the forms given to the spray by the reaction. It seems to me legitimate to infer that the American Fall at the time of its abandonment by the Horseshoe was not so advanced in position as to plunge into standing water, but had already retreated far enough to have acquired a talus above the level of the pool. At the present time the profile of the American Fall where its volume of water is greatest is approximately as shown in Fig. 19. The edge of the main river is at *S*, 220 feet horizontally from the crest of the fall at *C*, the intervening space being occupied by a gently sloping talus of large limestone blocks, among which the water descends in a labyrinth of cascading torrents (Fig. 18). At the initial stage, when the American Fall was first separated, the position of its crest was probably at some point, *I*, between its present position and the outer edge of the visible talus. As sketched, *I* is 160 feet from *C*, and if the total retreat of the American Fall in five hundred years was 160 feet the average rate of recession was 0.32 foot per annum. Allowance should be made for difference in rate dependent on the gradual encroachment of the protective talus upon the exposed cliff of shale, so that during the earlier part of the period the retreat was more rapid than during the later part. The indication, therefore, is that the present rate of recession is considerably less than 0.32 foot per annum, a result in harmony with that based on the maps and sketches.

The assumptions underlying each of the estimates are factors of such importance that neither result can claim a high measure of precision. It appears to be safe to say that the present average rate of recession of the American Fall can not be so great as 0.5 foot per annum, and is probably as small as 0.2 foot per annum, or about one twenty-fifth of the rate of recession of the Horseshoe Fall.

THE MAP OF 1842.

The detection of an important error in the outline of the American Fall as mapped in 1842 tends naturally to bring in question all other results of the survey of that year. Inasmuch as the outline of the Horseshoe Fall as determined in 1842 is one of the most important data used in the computation of the rate of recession, it has been subjected to critical examination and all practicable checks have been applied.

The framework of the survey includes two stations

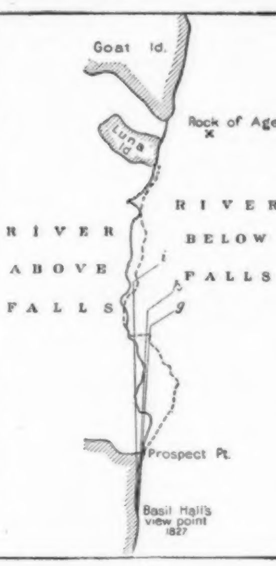


FIG. 17.—PLAN OF AMERICAN FALL.

A full line shows the crest as mapped in 1905; the broken line, as mapped in 1842; i, tangent to deepest re-entrant as sketched by Basil Hall in 1827; h, tangent to the re-entrant nearer Prospect Point 1827; g, tangent to salient between two re-entrants, 1827. Compare Figs. 12, 14 and 15.

or "trigonometrical points" on the American shore, three on Goat Island, and three on the Canadian shore. Those on Goat Island were connected, each with the next, by traverse lines, distances being measured by the surveyor's chain and courses observed by the surveyor's compass; so also were the two on the American shore. All other connections were made by compass bearings. From the 7 stations thus established the positions of 29 points on the crest lines were determined by intersections of compass bearings. In all the later surveys the bearings were presumably made with the engineer's transit or the plane-table alidade, instruments susceptible of much higher precision than the surveyor's compass; but in view of the shortness of the distances the relative weakness of the surveyor's compass does not seem to me an important factor.

The stations and other points are indicated on the published map, and there is a "table of observations." With the aid of these data positions of points on the crest lines were replotted as a check on the accuracy of the compilation and engraving of the map. This

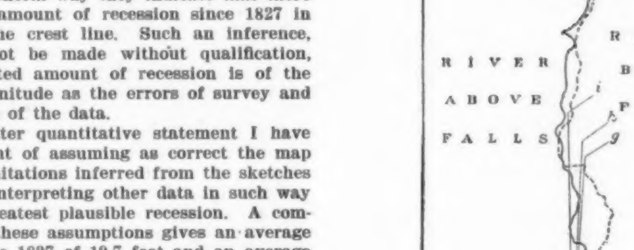


FIG. 19.—PROFILE AND SECTION OF AMERICAN FALL NEAR ITS MIDDLE PART. COMPARE FIGS. 1 AND 18.

work revealed three errors in the bearings as published, probably to be ascribed to copying or printing and not affecting the map. It indicated also that the points of the crest lines determined by intersection are not all accurately placed on the map, the errors amounting usually to a few feet, but not affecting the computed rate of recession.

Each of the crest-line points was originally located, as a rule, by the intersection of two bearings, but there are four points to which three bearings were taken. In the replotting of these points the check afforded by the third bearing was found to give a satisfactory result. The points which have the advantage of this check are all on the east side of the Horseshoe curve, and include the point at the angle of the Horseshoe in the position where the notch subsequently developed (Z in Fig. 6). For the remainder, or western part, of the Horseshoe curve there is no similar check, and the three located points of the crest line are so far apart as to give little mutual support. So far as the published data are concerned, these have no higher intrinsic authority than the two points on the American Fall which have been discredited by independent evidence.

The record of the Horseshoe Fall which stands nearest in time to the map of 1842 is Basil Hall's sketch from the Forsyth Hotel (Fig. 7), the interval being fifteen years. The general form of the crest line is the same in map and sketch, and the tangent based on the sketch is so related to the mapped crest line (Fig. 6) as to indicate some recession between the dates of the sketch and the map, but the amount of recession is less than would be expected.

The factors bearing on the estimate of the rate of recession are not so related that rigid mathematical methods can be applied to their discussion. The conflict of data and the mutual support of data can be weighed only by non-mathematical methods, and the result of their study is an opinion rather than a decision. The general tenor of the evidence, including the five surveys and the Basil Hall sketch, leaves no question that the annual rate of recession has been about 4 or 5 feet. If full authority be ascribed to the map of 1842, the estimated annual rate of recession is 5.3 feet. If full authority be ascribed to the tangent line based on the sketch of 1827, the estimated rate is about 1 foot less. It is my opinion that the map affords the better record. Giving to it the greater weight and to the tangent a smaller weight, I think the best practicable estimate of the rate is between 5.3 and 4.2 feet, but nearer to the former; and I select 5 feet partly because a statement in even feet avoids the implication of high precision which might be suggested by a decimal. As an estimate of the average rate of recession during the period of definite observation, I think this can not be in error more than 1 foot.

SUMMARY AND CONCLUSION.

The data for computing the rate of recession of Niagara Falls include surveys of the crest line made in 1842, 1875, 1886, 1890, and 1905, and camera lucida sketches made in 1827. During the period covered by these data the local conditions affecting the rate of recession have not differed to an important extent from the natural conditions. The present and prospective diversions of water for economic uses interfere with the course of nature and may be expected to modify the rate of recession. The natural rate of recession of the Horseshoe Fall is desired by geologists in connection with estimates of the age of the river. The geologic bearing of a rate modified by human agency is less direct. The rate of recession of the American Fall is of interest to geologists because somewhat representative of the river's activity in gorge making when the volume of water was much less.

The rate of recession of the Horseshoe Fall, or the rate of lengthening of the Niagara gorge, during the sixty-three years from 1842 to 1905 is found to be 5 feet per annum, with an uncertainty of 1 foot. For the thirty-three years from 1842 to 1875 the rate was apparently slower than for the thirty years from 1875 to 1905. The rate of recession of the American Fall during the seventy-eight years from 1827 to 1905 was less than 3 inches per annum.

The time consumed in the recession of the falls from the escarpment at Lewiston to their present position, or the age of the river, is not here estimated. It can not properly be computed without taking account of all conditions, local and temporary, affecting the rate of recession, and some of those conditions have varied greatly from point to point and from time to time.

AGNES MARY CLERKE.*

By E. A. Dent.

In the death of Agnes Mary Clerke, which took place on the 20th of January last, the scientific world lost one of its most useful and distinguished members.

Miss Clerke was one of the four eminent women upon whom, by virtue of scientific attainments, Fellowship in the Royal Astronomical Society has been conferred. The others were Miss Caroline Herschel, Mrs. Somerville, and Lady Huggins.

As a clear and forceful writer on astronomical subjects Miss Clerke was almost unrivaled. Her knowledge was deep and thorough; her outlook was broad, and her attitude as a student of the heavens fearless but reverent. Her original investigations covered many subjects, such as studies of star colors, star distribution, the classification of stellar spectra, variable stars, etc., but her great skill in compiling the results of the work of others, and her keen insight in comparing and discriminating as to the bearing and value of different classes of evidence, almost overshadowed her own investigations. The value of her books is enhanced by their charming literary style, fluent yet dignified language, and general grace of expression. They are notable as works of literature as well as of science.

Agnes Mary Clerke, daughter of John William Clerke, was born in the County of Cork, Ireland, on the 10th of February, 1842. Though her astronomical reading began when she was a child of eleven years, her education was not designed to fit her for scientific work. In reply to a question of the writer on the subject she said:

"The truth is bare and bold enough in sound, that in the scientific sense I had no education, but just picked up what came my way. I had a childish passion for natural knowledge and read the books accessible to me in my father's library, taught myself with the minimum of assistance some elementary mathematics, and that was all. I was also very delicate growing up and never went to school, . . . but I had admirable instruction from private professors in languages and music. I had from time to time tried writing stories and poetry, with indifferent success; but in Italy I undertook more serious work and contributed on various topics to the Edinburgh Review from 1877. An article on 'The Chemistry of the Stars' made a turning point. The studies for it revived my astronomical tendencies; Messrs. Black accepted my proposal to write for them a history of recent astronomy, and so I went on."

The publication of "A Popular History of Astronomy in the Nineteenth Century," upon which she spent the work of four years, brought her at once to the attention of the scientific world. The book was at once recognized as a most important contribution to astronomical literature. It reached its fourth edition in 1902, and has been translated into German.

"The System of the Stars," published in 1888, contains the result of several months' work at the Cape Observatory, studying the southern heavens under the guidance of Sir David Gill. The second edition, published in 1905, is largely re-written, in view of the progress which had been made in astronomical research since its first appearance. The same remark may be made of the "History," which was not permitted to become out of date.

"Problems in Astrophysics," published in 1903, deals essentially with twentieth century astronomical science. It embodies not only a history of what has been accomplished in astrophysical research, but it suggests the directions of possible and probable advance and development, stimulating the worker to further investigation. The Fellowship in the Royal Astronomical Society which was conferred upon the appearance of this book was no doubt intended as a public recognition of the value of her services to astronomy.

"The Herschels and Modern Astronomy," published in 1895, is a short history of the celebrated family and its contributions to astronomical science.

Shorter works are "Familiar Studies in Homer," published in 1892; two sections of "Astronomy" in the Concise Knowledge Series; the "Hodgkins Essay" on Temperature Research at the Royal Institution, 1901; about one hundred sketches of the lives of scientific men for the Dictionary of National Biography, and many of the articles in the Encyclopædia Britannica upon the life and work of such men as Galileo, Kepler, Laplace, etc.

The last work, published a year ago, was "Modern Cosmogonies." It is a review of the theories of the universe which have been advanced from time to time, with a discussion as to their merits and defects.

The London Times, commenting on the death of Miss Clerke, (February 22, 1907), said: "No worker in the vast field of modern sidereal astronomy opened by the genius of Herschel and greatly advanced by the application of the spectroscope to the chemical and physical problems of the universe lacked due recognition by Miss Clerke, who performed as it seemed no other writer could have done the work of collation and interpretation of this enormous mass of new material, ever pointing the way to new fields of investigation, often by one pregnant suggestion sweeping aside a whole sheaf of tentative conjectures, and indicating, if not the true line—for in many cases the truth is yet to seek—at least a plausible and scientific line well worth pursuing. She will be missed at the meetings of the Royal Astronomical Society, at which she was a constant visitor, . . . where her clear judgment was at times called upon to determine the value of some new suggestion in the domain of celestial physics."

* Journal of the Royal Astronomical Society of Canada.

FORMS FOR CONCRETE CONSTRUCTION.*

By Sanford E. Thompson, M. Am. Soc. C.E.

Recent failures in reinforced concrete construction cannot be cast aside and forgotten with the passing comment so frequently heard, that the accident was due merely to poor construction or too early removal of forms. The reasons for every failure should be thoroughly investigated by experts to prevent recurrence of similar accidents.

"Poor construction" and "forms," although frequently guilty, are by no means the only culprits. Just so long as men who know nothing of the first principles of mechanics are permitted to design concrete structures, and just so long as irresponsible contractors are engaged to erect them, the list of accidents will increase in startling numbers. It is the men—not the inanimate lumber—who are to blame in every case. However, granting its danger under ignorant hands, reinforced concrete as a whole must not be condemned for failures due to improper conditions any more than brick should be rejected as a building material for apartment houses because of the collapse of several unfinished buildings in New York city two years ago through disregard of frost action upon the mortar.

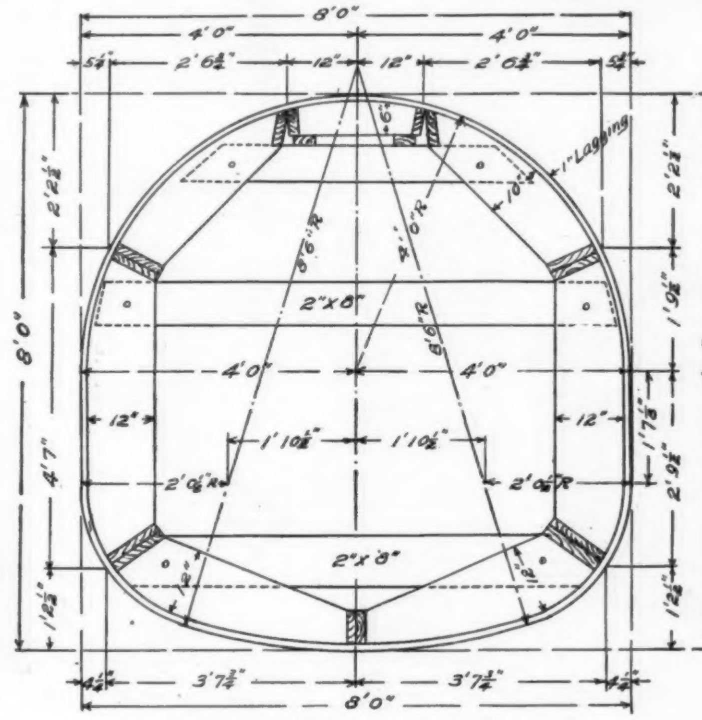


Fig. 1.—CENTER FOR 8 FOOT CONDUIT.

Failures in concrete buildings may be attributed to:

(1) Imperfect design; especially through neglect of essential details in locating the reinforcing metal, and through the adoption of too low a factor of safety.

(2) Poor materials; such as cement which does not properly set up, or sand which is too fine or which has an excess of clay, loam or other impurities.

(3) Faulty construction; from improper proportioning, mixing or placing, or too early removal of forms.

(4) Weak forms.

A disregard of such important principles is frequently criminal negligence, and yet in at least one case under my observation an examination of the structure and the materials after a collapse in which a number of lives were lost showed the design, materials and construction to be all so faulty that it was impossible to decide positively which of the four causes named above was the primary reason for the failure.

In this paper it is proposed to treat only of the design, construction and removal of forms.

GENERAL RULES FOR FORM CONSTRUCTION.

Kind of Lumber.—The selection of the lumber must be governed by the character of the work and the local market. White pine is best for fine facework, and quite essential for ornamental construction cast in wooden forms. For ordinary work, however, even for

* Paper read before the Third Convention of the National Association of Cement Users.

the panels, white pine is apt to be too expensive, and spruce, fir, Norway pine or the softer qualities of Southern pine must be substituted for it. Some of these woods are more liable to warp than white pine, but they are generally stiffer and thus better adapted for struts and braces.

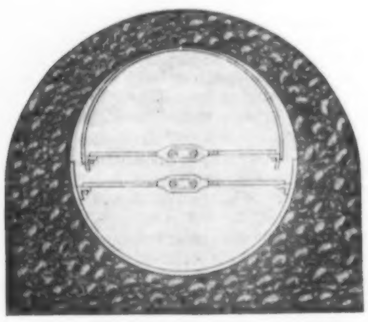
Kiln dried lumber is not suitable for form construction because of its tendency to swell when the wet concrete touches it. Very green lumber, on the other hand, especially Southern pine which does not close up quickly when wet, may give trouble by joints opening. Therefore, the middle ground, or, in other words, partially dry stuff, is usually best.

Finish and Thickness of Lumber.—Either tongued-and-grooved or bevel-edged stuff will give good results for floor and wall panel forms, and is preferable to heavy construction where derricks are used 2-inch is preferable, while for small panels 1-inch boards are lighter and easier to handle. For floor panels 1-inch boards are most common, although if the building is eight stories high or over, 1-inch stuff of soft wood is likely to be pretty well worn out before the top of the building is reached, and the under surface of the concrete will show the wear badly. For sides of girders either 1-inch or 1½-inch is sufficient, while 2 inches is preferable for the bottoms of girders. Column forms are generally made of 2-inch plank.

DETAILS OF FORM CONSTRUCTION.

Certain general rules are applicable to all kinds of forms. Strength, simplicity and symmetry are three fundamental principles of design. The necessity for so that the column forms and also the bottom of beam molds are all independent of the slabs. The forms may thus be left a longer time upon members subjected to the greater stress.

The sides of the beam forms should be held tightly together, by wedges or clamps, to prevent the pressure of the concrete springing them away from the bottom boards. Hardwood wedges at top or bottom of each strut are useful when setting and removing it, and also permit testing to make sure that there is no deflection of the beam or slab. For this purpose some contractors loosen the wedges twenty-four hours in advance of the struts. In general it is preferable to use comparatively light joists, such as 2 inches by 8 inches or 2 inches by 10 inches, with frequent shores rather than to use lumber which is heavier to handle.



"BLAW" CENTERS COLLAPSED.

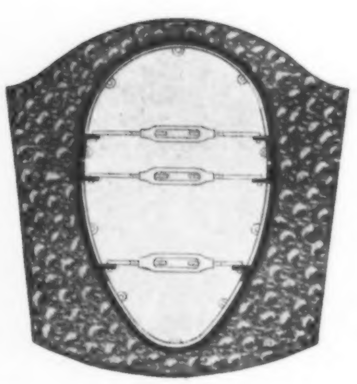


FIG. 2.—"BLAW" CENTERS IN POSITION

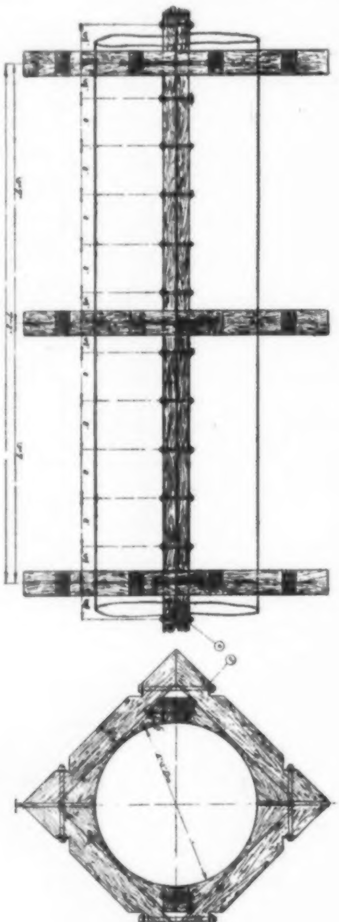


FIG. 3.—STEEL FORMS FOR PIERS IN THE PITTSBURG FILTRATION GALLERY.

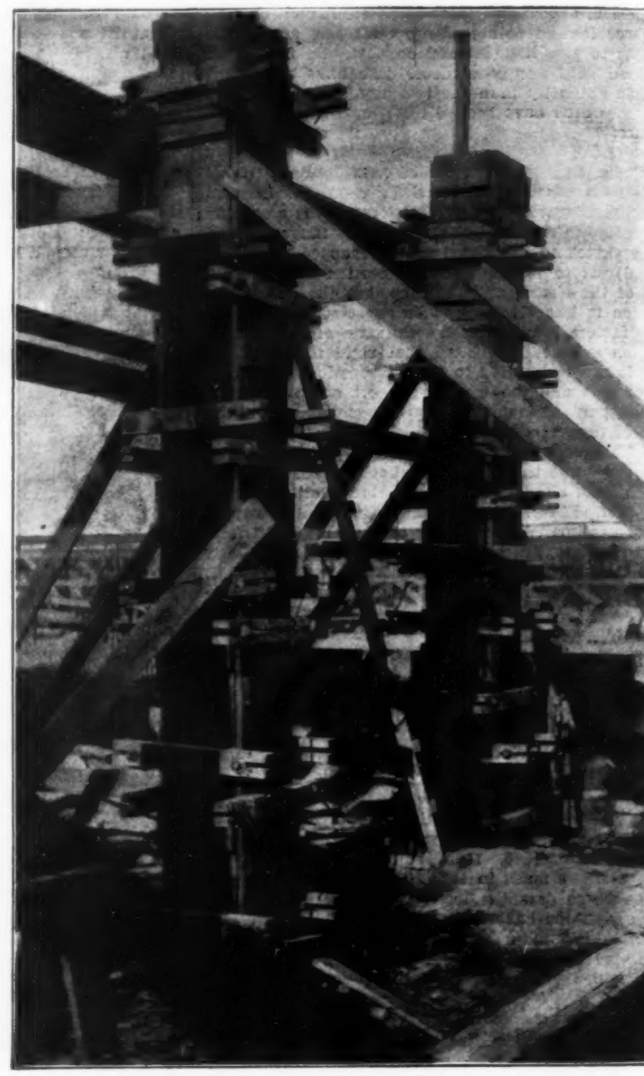


FIG. 4.—MOLDS FOR COLUMNS AT HARVARD STADIUM.

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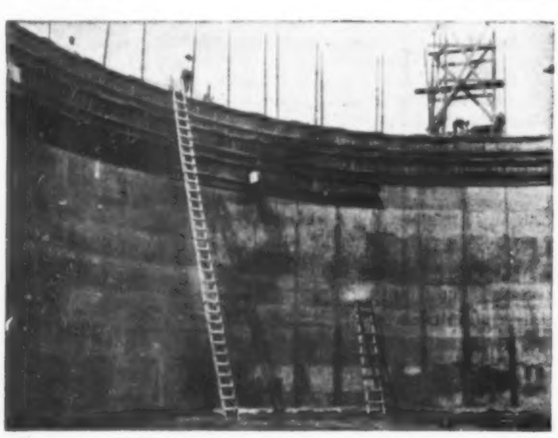

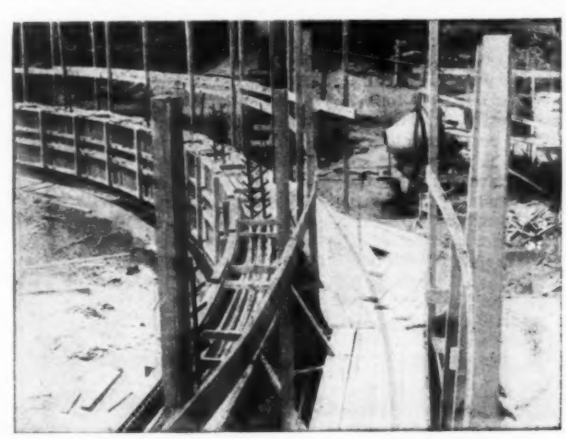

FIGS. 5 AND 6.—FORMS FOR CONCRETE RESERVOIR, WALTHAM, MASS

square-edged stuff. A smoother surface may be attained at first with the tongued-and-grooved stock than with square or bevel edge and there is less trouble with opening joints, but it is more expensive because of the waste in dressing, and if the forms are used many times there is greater tendency to wear at the joints. Even for rough forms plank planed one side may be economical to cheapen the cost of cleaning. Studs should always be planed one side to bring to size.

The thickness of lumber varies with different contractors, some using 1 inch, others 1½ inch, while a few employ 2-inch stuff even for panels. (These are commercial thicknesses measured before planing.) For ordinary walls 1½-inch stuff is good, although for strength is obvious. Economy in concrete construction consists in quickly erecting and moving the forms and in using them over and over again.

The design of the concrete members should recognize the forms. A slight excess of concrete sometimes may be contributed to save carpenter work. Frequently beams may be designed of such widths as to use dimension widths of lumber without splitting.

Columns may be of dimensions to avoid frequent remaking. Recesses may be made the thickness of a board or a plank. To permit ready cleaning of dirt and chips from the column forms before laying the concrete, at least one prominent contractor provides a door at the bottom of each of them.

In building construction the forms must be designed

If forms are to be used but once, or must be taken apart when removed, it is sometimes practicable to use only a few partially driven nails so that they can be withdrawn without injury to the lumber. It is very difficult to convince house carpenters that the pressure of concrete will hold temporary panel boards in place with scarcely any nailing.

Alignment is another item of importance, since it is here that a great deal of time may be wasted by inexperienced or incompetent carpenters. Such workmen may err either on the side of poor alignment or more careful alignment than the structure requires. Mr. W. J. Douglas* suggests as a general rule the allowance of

* Engineering News, December 20, 1906, p. 648.

"¾-inch departure from established lines on finished work and 2 inches on unfinished work."

In removing forms the green concrete must not be disturbed by prying against it. This seems so obvious as to need no emphasis, but I have known first-class carpenters to actually attempt to straighten a wall which was an inch out of line the day after the concrete was laid by prying the forms over. The wall was straightened, but by a different process from that proposed by the carpenter—the concrete was relaid.

Forms for facework should be tightly put together, be thin enough to flow and fill the grain of the wood.

If the forms are to be left on until the concrete is hard, there is little danger of the concrete sticking to them if they are wet thoroughly with water before the concrete is laid instead of being greased. In any case, if concrete adheres to the forms it should be thoroughly cleaned off before resetting; even then it is apt to stick again in the same place.

DESIGN OF FORMS.

"Rule-of-thumb" layout of forms in the field is being superseded by design in the drawing room. In building construction where the forms form a large percentage of the cost of the building, and where a failure in the forms may cause loss of life, it is especially necessary to treat this question from an engineering standpoint, and many of the best concrete contractors now design their forms as carefully as the dimensions of the concrete members.

If a minimum quantity of lumber is to be used consistent with the deformation allowed, it follows that the dimensions and spacing of the supporting lumber must be actually computed from the weight or pressure against the sheeting. For columns and for walls where a considerable height of wet concrete is to be placed at once, the pressure may be calculated as a liquid. Mr. W. J. Douglas* assumes that the concrete is a liquid of half its own weight, or 75 pounds per cubic foot.

In ordinary walls, where the concrete is placed in layers, computation is not usually necessary, since general experience has shown that maximum spacing for 1-inch boards is 2 feet, for 1½-inch plank is 4 feet, and for 2-inch plank is 5 feet. Studding generally varies from 3 x 4 inch to 4 x 6 inch, according to the character of the work and the distance between the horizontal braces or walling. 4 x 4-inch is the most useful size.

Floor forms are better based upon an allowable deflection than upon strength, in order to give sufficient stiffness to prevent partial rupture of the concrete or sagging beams.

In calculating we must add to the weight of the con-

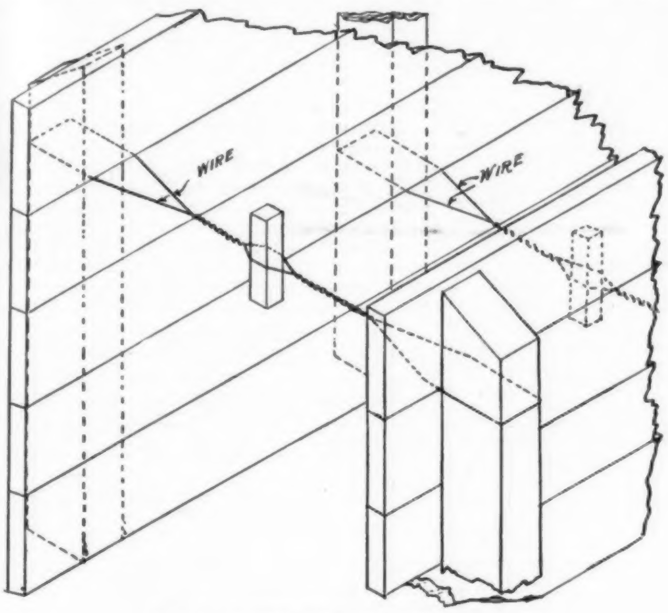

FIG. 7.—FORM FOR HEAVY WALL.

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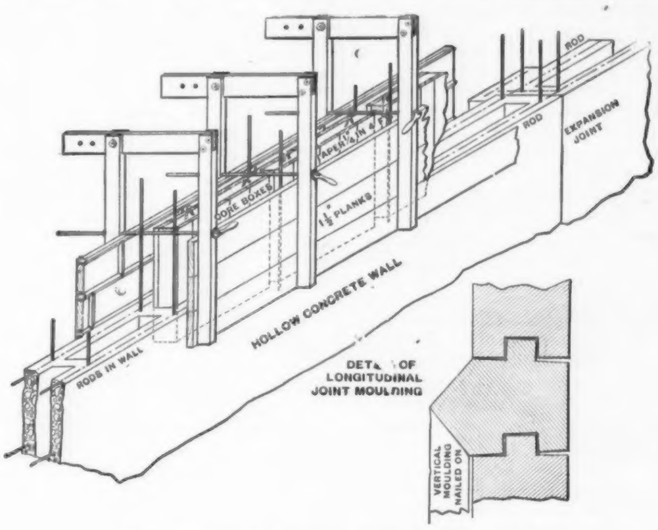

FIG. 10.—FORMS FOR HOLLOW WALLS.

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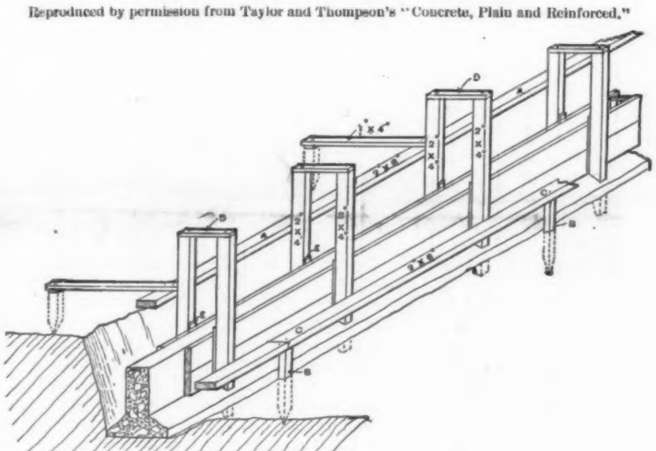

FIG. 8.—FORM FOR CELLAR WALL.

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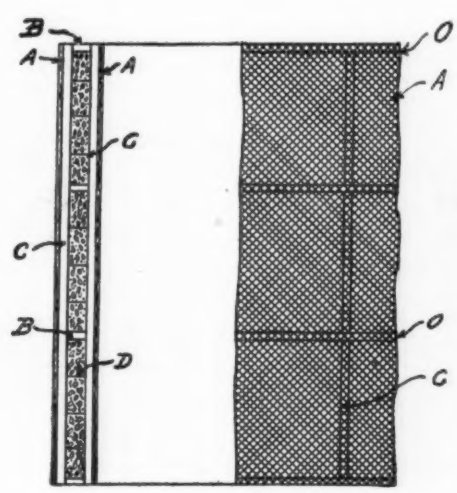

EXPLANATION.

A= Wire Fabric.
B= Spacing Bar.
C= Vertical Member.
D= Separator.
O= Horizontal Member.

A frame of the desired form is erected of structural steel and covered with wire fabric as shown. A coating of cement or mortar is then applied to the outside of the wire fabric which, upon hardening, forms a shell of the desired outline, which may be filled in with concrete. This method of construction does not require the use of forms or molds, thus effecting a great saving in material and labor, besides affording a strong well-finished structure. It may be employed in building dams, retaining walls, culverts and other structures.

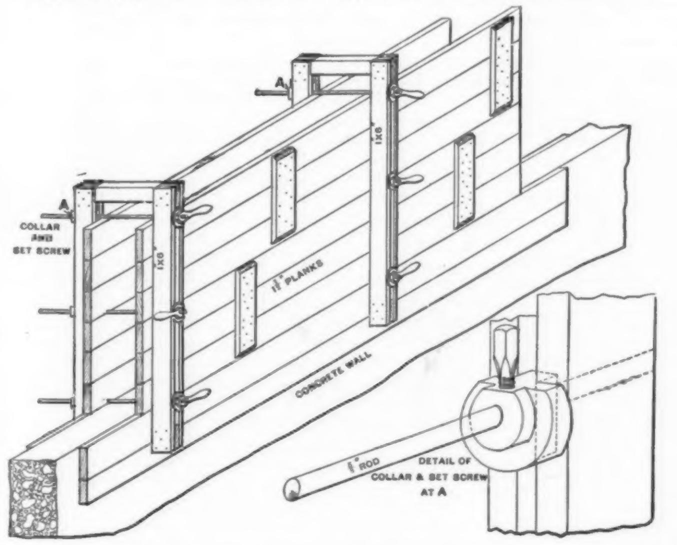

FIG. 9.—MOVABLE WALL FORMS.

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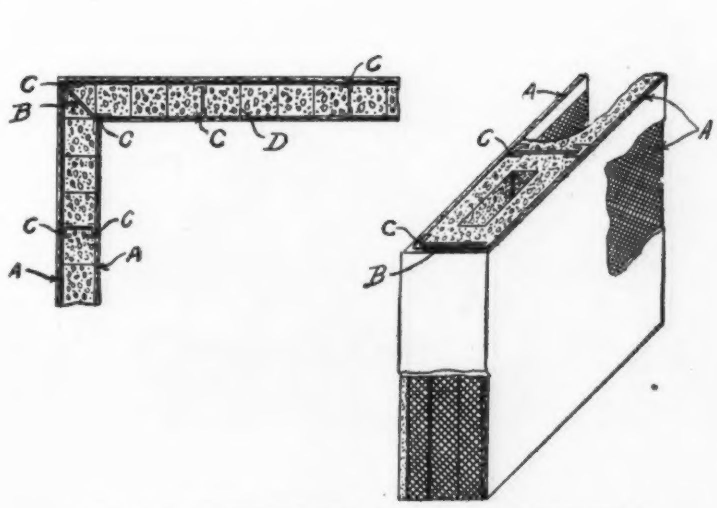

FIG. 11.—CONCRETE-METAL WALL CONSTRUCTION.

it being advisable in some cases to close the joints and holes by mortar, putty, plaster of Paris, sheathing paper or thin metal. This is not, as is commonly supposed, to prevent loss of strength by the cement which flows out with the water, but rather to prevent the formation of voids or stone pockets in the finished surface.

Crude oil is one of the best materials to prevent adhesion of the concrete to the forms, though linseed oil, soft soap and various other greasy substances are also employed for this purpose. The oil or grease should

* Engineering News, December 20, 1906, p. 646.

crete itself—i. e., to the dead load—a construction live load which may be assumed as liable to come upon the concrete while setting. Definite units of stress must also be assumed in the lumber.

I would suggest the following basis for computation, these being values which I have adopted for use:

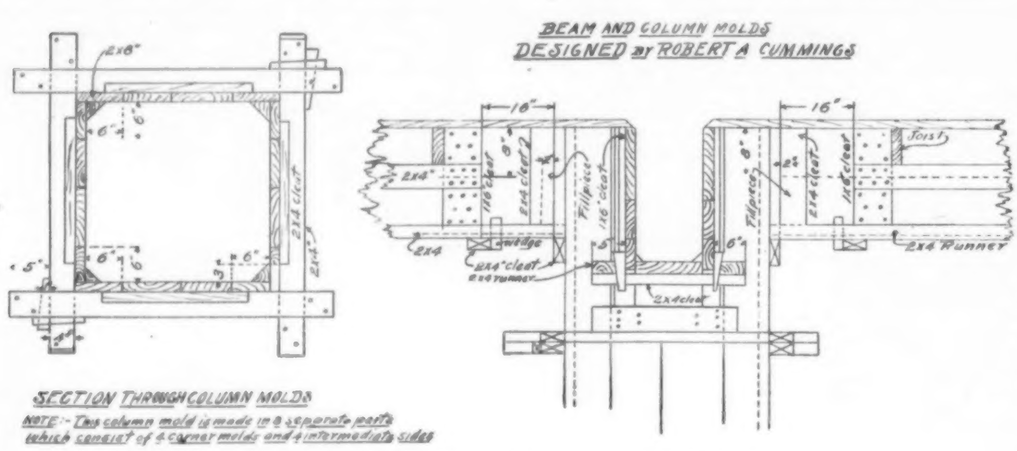

FIG. 12.—TYPICAL FORMS IN BUILDING CONSTRUCTION.

(1) Weight of concrete, including reinforcement, 154 pounds per cubic foot.

(2) Live load, 75 pounds per square foot upon slab, or 50 pounds per square foot in figuring beam and girder forms.

(3) For allowable compression in struts use 600 to 1,200 pounds per square inch, varying with the ratio of the size of the strut to its length. (See table below.) If timber beams are calculated for strength, use 750 pounds per square inch extreme transverse fiber stress.

(4) Compute plank joists and timber beams by the following formula, allowing a maximum deflection of ⅛ inch:

$$d = \frac{3}{384} \frac{Wl}{EI} \qquad (1)$$

$$\text{and } I = \frac{bh^3}{12} \qquad (2)$$

in which

d = greatest deflection in inches;
W = total load on plank or timber;
l = distance between supports in inches;
E = modulus of elasticity of lumber used;
I = moment of inertia of cross-section of plank or joist;
b = breadth of lumber;
h = depth of lumber.

The formula is the ordinary formula for calculating deflection except that the coefficient is taken as an approximate mean between 1/384 for a beam with fixed ends and 5/384 for a beam with ends simply supported.

For spruce lumber and other woods commonly used in form construction, E may be assumed as 1,300,000 pounds per square inch.

Formula (1) may be solved for I, from which the size of joist required may be readily estimated.

The weight of concrete per cubic foot is somewhat higher than is frequently used, but is none too much where a dense mixture and an ordinary percentage of steel are used. For very rough calculation, however, it is frequently convenient to remember that 144 pounds per cubic foot is equivalent to the product of the dimensions of the beam in inches times a length of one foot.

The suggested live load is assumed to include the weight of men and barrows filled with concrete, and structural material which may be piled upon the floor, not including, however, the weight of piles of cement or sand or stone, which should never be allowed upon a floor unless it is supported by concrete sufficiently strong to bear the weight, or by struts under all the floors below.

The units for stress in struts are somewhat higher than in timber construction because the load is a temporary one. The extreme variation given is due to the fact that when a column or strut is longer than about sixteen times its smallest width there is a tendency to bend, which must be prevented, either by bracing it both ways or allowing a smaller load per square inch.

For struts ordinarily used the following stresses may be assumed for different heights:

SAFE STRENGTH OF WOOD STRUTS IN FORMS FOR FLOOR CONSTRUCTION.

Length of Strut.	Pounds per Square Inch of Cross-Section.			
	3 in. x 4 in.	4 in. x 4 in.	6 in. x 6 in.	8 in. x 8 in.
14 feet....		700	900	1100
12 feet....	600	800	1000	1200
10 feet....	700	900	1100	[illegible]
8 feet....	850	1050	1200	[illegible]
6 feet....	1000	1200	1200	1200

Bracing both ways will, of course, reduce the length of a long strut.

If the concrete floor is comparatively green, the load must be distributed by blocking, preferably of hard wood. At the top of the strut provision must be made against crushing of the wood of the plank or cross-piece. Ordinary soft wood will stand without crushing only about 700 pounds per square inch across the grain, so if the compression approaches this figure brackets must be inserted or hard-wood cleats used.

TIME TO MOVE AFTER PLACING.

The best contractors have definite rules for the minimum time which the forms must be left in ordinary weather, and then these times are lengthened for changes in conditions according to the judgment of the foreman.

Conference with a number of prominent contractors in various parts of the country indicates substantial agreement in the minimum time to leave forms. As a guide to practice the following rules are suggested, these following in the main the requirements of the Aberthaw Construction Company:

Walls in mass work: one to three days, or until the concrete will bear pressure of the thumb without indentation.

Thin walls: in summer, two days; in cold weather, five days.

Slabs up to 6 feet span: in summer, six days; in cold weather, two weeks.

Beams and girders and long span slabs: in summer, ten days or two weeks; in cold weather, three weeks to one month. If shores are left without disturbing them the time of removal of the sheeting in summer may be reduced to one week.

Column forms: in summer, two days; in cold weather, four days, provided girders are shored to prevent appreciable weight reaching columns.

Conduits: two or three days, provided there is not a heavy fill upon them.

Arches: of small size, one week; for large arches with heavy dead load, one month.

All of these times are, of course, simply approximate, the exact time varying with the temperature and moisture of the air and the character of the construction. Even in summer, during a damp, cloudy period,

FIG. 15.—POURING SEAT SLAB OF HARVARD STADIUM.

Reproduced by permission from Taylor and Thompson's "Concrete, Plain and Reinforced."

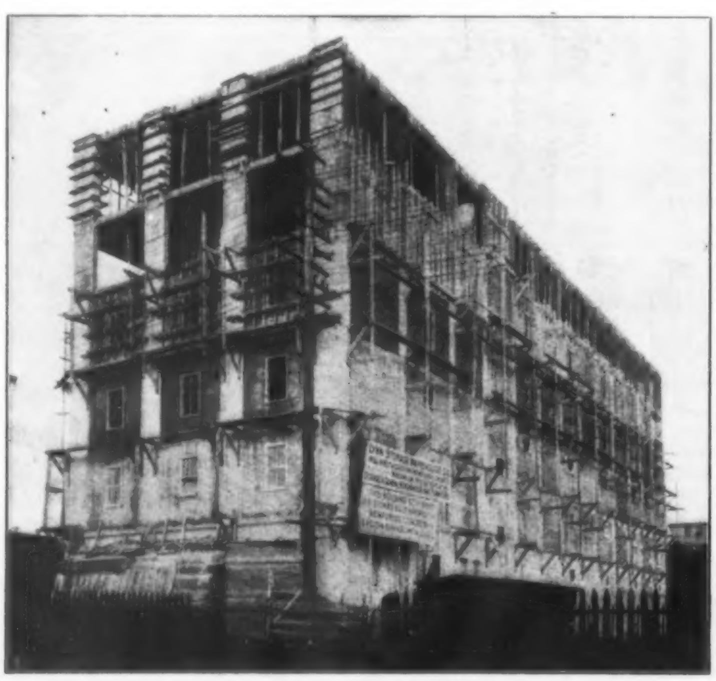

FIG. 14.—PANEL FORM CONSTRUCTION IN STORAGE WAREHOUSE, LYNN, MASS.

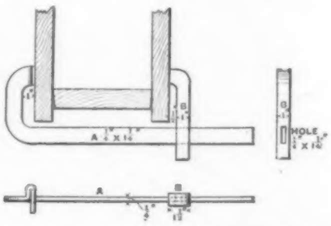

FIG. 13.—CLAMP FOR BEAM OF SMALL COLUMN FORM.

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wall forms sometimes cannot be removed inside of five days, with other members in proportion. Occasionally, too, batches of concrete will set abnormally slow, either because of slow setting cement or impurities in the sand, and the foreman and inspector must watch very carefully to see that the forms are not removed too soon. Trial with a pick may assist in reaching a decision.

Beams and arches of long span must be supported for a longer time than short spans because the dead load is proportionately large and therefore the compression in the concrete is large even before the live load comes upon it.

The general uncertainty and the personal element which enters into this item emphasize the necessity for some more definite plan for insuring safety. The suggestion has been made that two or three times a day a sample of concrete be taken from the mixer and allowed to set on the ground under the same conditions as the construction until the date when the forms should be moved. These sample specimens may be then put in a testing machine to determine whether the actual strength of the concrete is sufficient to carry the dead and construction loads. Even this plan does not provide for the possibility of an occasional poor batch of concrete, so that watchfulness and good judgment must also be exercised.

EXAMPLES OF FORM DESIGN.

I have selected a number of illustrations of typical modern form construction.

The center of an 8-foot conduit used by the T. A. Gillespie Company in the Pittsburg Filtration System is shown in Fig. 1. You will notice that the form is built in sections, bolted together, so as to be easily taken apart.

The patented Blaw centering is illustrated in Fig. 2. The shell is of steel with turnbuckles provided to collapse the metal, as shown in the upper section of the figure.

In the Pittsburg filter galleries a very large number of columns were erected for supporting the groined arch roof. Many of these columns were molded in steel centering shown in Fig. 3, this being economical because of the number of times it could be used over and over.

A more common style of column forms is that employed in the erection of the Harvard Stadium, as shown in Fig. 4. The slotted form of clamp does not give such stiff centering as another type, shown in Fig. 12.

In Waltham, Mass., a concrete reservoir or standpipe 100 feet in diameter by 42 high has recently been constructed under the direction of Mr. Bertram Brewer, city engineer. The forms designed by the contractors, Simpson Brothers Corporation, are shown in Figs. 5 and 6.

Fig. 7 illustrates the construction of a heavy wall where the ties consist of wire twisted to hold the side forms in place.

A simple form of construction for a low foundation wall is given in Fig. 8.

Fig. 9 illustrates a common form for building a wall of greater height. As soon as a section is completed the bolts are loosened and the slotted form of clamp or brace originally designed by Mr. E. L. Ransome permits it to be readily moved upward.

Forms for hollow walls are shown in Fig. 10.

A style of wall construction has been designed and patent applied for by Mr. S. H. Lea, using for the forms metal lathing which has first been plastered on the outside. (See Fig. 11.)

Beam and column forms such as are used in ordinary building construction are shown in Fig. 12. This is a common type with certain features designed by Mr. Robert A. Cummings, from whose drawings the sketch has been made. To hold the sides of the beam forms against the bottom board Mr. Cummings uses a 2-inch by 4-inch runner with wedges against it. The column form shown in the same figure is provided with wedges, which permit very firm and solid construction.

A clamp which is much used by the Ferro-Concrete Construction Company, of Cincinnati, is shown in Fig. 13.

A somewhat different type of beam and slab form has been designed by Mr. Benjamin Fox. The forms for each panel are made in two sections and supported at the center so that they may be dropped without disturbing the bottom plank of the beams and girders. The beams and girders are stiffened by 6-inch by 8-inch and 8-inch by 8-inch timbers placed underneath them and supported by posts varying in size from 4-inch by 4-inch to 8-inch by 8-inch, according to the load to be carried.

Wall panels in a concrete building are most cheaply constructed after the columns are built. Practical methods as adopted by the Eastern Expanded Metal Company, of Boston, are shown in Fig. 14. It also shows quite clearly the other portions of the form construction.

Fig. 15 is a photograph of the pouring of a slab in a sand mold at the Harvard Stadium by methods adopted by the builders, the Aberthaw Construction Company.

(We are indebted to Concrete Engineering for the use of cuts Nos. 1, 2, 5, 6, 11 and 14.)

A mammoth, one of the giant elephants that roamed North America thousands of years ago, will probably be one of the exhibits at the Alaska-Yukon-Pacific Exposition. It will be brought down from its present resting place in the pristine blue ice of an Alaskan glacier. The body of the pre-historic monster was discovered some time ago. The mammoth's carcass is intact in the ice, where it has rested for thousands of years.

SCIENCE NOTES.

Precious Stones in Plants.—Among the many strange things to be found in the new possessions of the United States, the Philippine Islands, are the so-called "plant stones" encountered now and again, in certain vegetable growths. The bamboo, for instance, according to Kultur und Natur, contains a stone very similar to the opal, but on account of the rarity with which it is found, much more costly than the opal. In many thousand cane stalks cut down and carefully examined, there may perhaps be one in which this beautiful greenish-pink, scintillating stone has been formed from the minute particles of silicious deposit that imparts its intense hardness to the outer covering of the cane. The bamboo-cane stone is known as *Tabashirs*. In the interior of some cocoa nuts, a stone-like secretion is found, that is not inferior in brilliancy to the most beautiful genuine pearl. The cocoa nut "pearl" is obtained by exposing the snow-white spongy mass, found in the perfectly ripe nut in addition to the milk and the kernel, in a wooden vessel, to the heat of the tropical sun and then removing the oily fluid present by pressure. In the residual tough paste, we find, occasionally only, it must be admitted, small, bluish, glittering spheres, ranging in size from a pin head to a pea. About a dozen of these exceedingly beautiful pearls, all of which were found in the Philippines, are kept as valuable treasures in some of the European museums.

Science, it is sometimes said, advances so rapidly nowadays that it is almost impossible to keep pace with progress. There are, however, cases where its rate of progress is tortoise-like rather than hare-like; not, we hasten to add, from any slackness on the part of its devotees, but from difficulties connected with the acquisition of specimens and the time necessary for the investigations. A remarkable instance of this slowness is afforded by the investigations connected with the existence of the teeth in the Australian platypus, or duckbill. The existence of such teeth was first announced by Prof. E. B. Poulton, of Oxford, so long ago as the year 1888, and yet it has taken from that time to this to ascertain how many of such teeth (or, rather, germs of some of them) the creature really possessed, and even now there are some points requiring further elucidation. Hitherto the number of teeth has been supposed to consist of either three or four pairs in each jaw, but Messrs. Wilson and Hill, in a paper recently contributed to the Quarterly Journal of Microscopical Science, have demonstrated that the set functionally developed originally consisted of five pairs. Of far more importance is their discovery that this functional series was preceded by a simpler series of milk-teeth. It therefore, follows that the platypus, and probably also its sole living relatives the spiny anteaters, or echidnas, are descended from mammals (or, shall we say, half-mammals and half-reptiles?) with a complete double series of teeth; the toothless condition of the adults of both being a purely adaptive character.

How long will volcanoes continue to spout fire and ashes on the surface of our earth? A writer in Knowledge quotes a recent pronouncement of Lord Kelvin at a meeting of the Royal Society of Edinburgh. Lord Kelvin said that volcanoes might be expected to continue so long as there was any molten rock in the interior of the earth, though he was of opinion that solid matter constituted much the greater part of the whole mass of the earth. And, even after all the molten rock has been squeezed out in the forms of volcanoes, and has formed solid lava, there would still be a shrinkage of the hot, solid interior, which would leave cavities beneath the cool surface of the earth. Earthquakes would then occur on an increasing scale of magnitude, as volcanoes decreased. This would go on until the very central region was cooled; till the whole earth became solid. All this, of course, would depend upon there being no violent collision of the earth with another globe, when "the elements would melt with fervent heat." According to Lord Kelvin's theory, there can be earthquakes without lava, only subsidation. The crust of the earth is cool and hard, with an interior increasing in temperature. Slow though it be, there is an escape of heat. The interior must be shrinking more than the crust. The hard outer crust would gradually be dragged inward and vast cavities would be made. The solid earth being undermined in some places seemed to be an explanation of earthquakes. However, after an earthquake on a large scale there would be a lowering of level, or an absolute engulfing, as was the case with the small island off the northwest coast of Sumatra.

Messrs. Lumière and Seyewetz have recently been estimating how many plates may be safely fixed in a certain bulk of fixing bath, and although their actual figures are, in our opinion, of neither theoretical nor practical interest, they have found some facts that are well worth notice. Their figures are not of practical interest because a hundred plates of a certain size fixed in a liter of a certain strength is not a definite statement. It is not the superficial area of plate, but the amount of silver salt that is important, and the two are not proportional. Nor is it well to use a fixing bath to a calculated extent. Unless a fresh portion is taken for every two or three plates, so that the solution is a very long way from the possibility of its being used too much, two portions should be used, fixing in the first until the plate is clear, and then soaking it for about an equal time in the second. When the first begins to work slowly it is discarded, the second solution takes its place, and a fresh portion is taken into use for the second. The chief fact of interest that these experiments have led to is that the acid fixing bath used was found to have only half the fixing power of a plain solution of sodium thiosulphate before it becomes unsafe. This, therefore, emphatically supports the opinion that I have expressed for many years, that acid fixing and clearing baths are dangerous—tending to a want of permanence in the negative. It is curious, however, to note that the addition of a little chrome alum to the acid fixing bath increases its safe fixing power, and shows a loss of only twenty-five per cent instead of fifty per cent of usefulness. The effect of incomplete fixation may take months, if not years, to show itself, but if before it becomes obvious any change is needed in the negative, such as intensification, then the impure film gives an irregular result and perhaps a hopelessly stained negative. The fixing bath employed in the above experiments was acidified by the simple addition of a little sodium bisulphite, which is perhaps the least objectionable of the various methods proposed for preparing such a solution.—Knowledge.

ELECTRICAL NOTES.

Proper Lightning Protectors.—In an address to the Royal Engineers at Chatham, Mr. Alfred Hands said that too much importance is attached to the form and composition of lightning-conductors, and not enough to the fact that the efficiency depends almost entirely on the way the apparatus is attached and little on what it is made of. Lightning-conductors in the hands of experts, he said, may be likened to drugs in the hands of doctors—they must be suited to the particular case. As to the relative value of iron and copper for conductors, there is but a trifling difference, except that for conductors expected to last long iron is too perishable.

Attention is called to an interesting project prepared by Mr. B. H. Thwaite, and submitted to the Parliamentary Committee on the London County Council Electric Supply Bill. The proposal was to use a current of 60,000 volts and to bring it into London over a distance of 120 miles from the coal fields. To generate the electricity it was proposed to use gas engines driven by producer gas. It was proposed to use cheap slack and the cost per ton would be only two-fifths of the cost of the fuel used by London electric generators taking average prices. The sale of by-products would realize 2s. 6d. per ton. The land on which the generating station would be erected would be cheaper, and the saving in rates on about 100,000 kilowatt capacity would be about £45,000 a year, or about 9s. a year per kilowatt, or 0.033d. per unit sold. Another plan proposed by Mr. Arthur J. Martin provides for the distribution of gas under pressure as the means of conveying power from the coal fields in South Yorkshire to London. The scheme involves a transmission pipe line of over 173 miles, the gas being compressed to 500 pounds per square inch. At this pressure, 40,000 millions of cubic feet, which is the yearly consumption of gas in greater London, could be conveyed by a single line of pipes 25 inches in diameter. The horse-power required to compress the gas would be as much as 40,000 and the cost of the pipe laying, including all incidental expenses, would be roughly (£) 1,500,000. The annual cost of compression and transmission, including interest and depreciation, works out at 1 1-3d. per 1,000 feet, and it is estimated from these and other figures that gas could be delivered in bulk to the existing companies at 7½d. per 1,000 cubic feet, and would thus enable them to retail it at a figure which they cannot now approach.

While there is apparently no end to the number of auxiliary appliances which can be installed in a power house, says the Electrical Review, experience in actual operation shows that there is a limit beyond which it is undesirable to go in the failure to make use of well-tried devices designed to promote economy of fuel consumption or to forestall the effects of accidents. The motor-driven steam valve stands in the latter class of apparatus; it has made a good record in the few plants where it has been installed, and on the score of convenience and flexibility its results in service are far beyond the possibilities of hand operation. Yet on account of the cost of installing electrically-driven valves, or perhaps from an inert appreciation of their advantages, their use has not extended very rapidly in railway service, but now and then operating experience shows the importance of such control of at least the high pressure steam lines. A case in point occurred recently in a power plant supplying the car service of a city of considerably over 100,000 inhabitants. In the early evening a tube burst in one of the boiler batteries, a large quantity of water was at once let loose on the fires and the boiler room filled with dense steam. It was impossible to enter the room to cut off the injured boiler from the rest and start the fires beneath the others; there was a complete shut-down of the generating units, and for about an hour every car on the system was at a standstill. The loss of earnings during this hour based on the average hourly income of the system from passenger traffic was something in excess of $200, leaving out any consideration of wages and fixed charges, and the direct cost of the damage to the boiler room equipment. Matters were remedied by smashing in the skylights in the roof of the station, which allowed the steam to escape and made the boiler room habitable again so that the damaged boiler could be shut off and fires started on cold water in the others. If a small, rugged induction motor had been attached to the valve between each boiler and the main header with remote control in both boiler and engine rooms, the trouble would probably have lasted but a few moments.

TRADE NOTES AND RECIPES.

Shoe Cream.—A waterproof shoe cream can be made by melting together 1 part of rosin, 4 of fish oil, and 10 to 12 of hog's fat (lard). To impart a yellow color, digest the melted mass with powdered turmeric and strain. The mass may be made black by stirring it with lampblack.

To Give a Polish and Black Color to Iron and Steel.—After removing all dirt and rust from the article proceed as follows: Mix 1 part of copper sulphate with 16 of water, adding ammonia till the copper sulphate is entirely dissolved. Then mix 1 part of stannic chloride, 2 of water, and 2 of hydrochloric acid, preferably in an earthenware vessel. Immerse the article first in the latter and then in the former solution, and a firmly adhering coating will be deposited on the iron. Now wash the article and dip it in a solution of hydric sulphide with ammonium sulphide; a deep black coating will be formed, which can be brushed and polished without coming off.

To Remove Splashes of Oil Paint.—The unsightly splashes of oil paint, which are liable to come on window panes during painting operations and which are very difficult to remove, will disappear when treated with black soap; turpentine oil and soda are not sufficient. All oil paints can be dissolved with black soap; the latter should be spread on the spots and allowed to remain on them for several hours. Brushes which have become hard and stiff with oil paint can be rendered soft by the same means; they should be well rinsed afterward in clean water. It is not advisable, according to the Deutsche Tischlerzeitung, to remove oil paint from glass with potash, lime, or other acrid substances, as the glass is apt to become tarnished in this way.

Practical Utilization of Varnish Skins.—In the boiling of linseed oil, and especially when substances transmitting oxygen are added, skins are formed, partly during the boiling process itself, but principally after the boiler is emptied, on the walls and then in the storage vessels. These skins increase considerably in thickness toward the bottom in a comparatively short space of time, though the oil ought to be protected by the first layer of skin, and they hitherto in most cases have been thrown away or used for quite subordinate purposes. They can, however, when not completely dry, be dissolved with comparative ease in volatile solvents such as turpentine oil, benzine, etc., and a very smooth, well-drying oil is thus obtained, very suitable for waterproof varnish and for pure oil varnish colors. The skins can also be boiled in linseed oil, giving an excellent varnish, and leaving as a residue thin brown shreds of skin, which are useless and may be burned. Varnish skins can even be dissolved in turpentine oil with careful heating, and in this way again transformed into a useful varnish, leaving only a slight residue.

Hemp and Hempseed Oil as Protectives Against Vermin.—It ought to be more generally known that hempseed oil can be recommended as a safe and speedy means of getting rid of the parasites which infest the skins of animals. A farmer writes: "I have used this protective for thirty years, and always with complete success. In two to three hours after the oil has been rubbed into the skins of domestic animals the troublesome itching ceases; the vermin have been exterminated. The oil is also very effective against lice. It is cheap and easily procurable and does not, like other substances of this kind, possess poisonous properties. It can therefore be safely used with horses as a preservative against horse flies, etc., also with cats and dogs, which are apt to lick off the oil. My long experience has shown that it is particularly useful with poultry. In gardens also hempseed may render effective service as a protective against earth-fleas, e. g., in keeping these insects away from cabbage seedlings. Hempchaff has a similar action. Hemp is also a pretty plant and will contribute to the adornment of the garden."

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